THE RELATIONSHIP OF INTERROGATIVE SUGGESTIBILITY TO MEMORY AND ATTENTION

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Summary

This study combined an individual differences approach to interrogative suggestibility (IS) using various paradigms (GSS, DRM, PEMQ) and questionnaires (free recall, recognition, and five-factor personality), including Event Related Potential (ERP) recordings to examine two alternative hypotheses regarding the source of individual differences in IS: (i) differences in attention to task-relevant vis-à-vis task-irrelevant stimuli; (ii) differences in one or more memory process, indexed by ERP old/new effects. Participants (N=405) were screened, and those with extremely low or high suggestibility went on to participate in the ERP experiment. Ninety-seven participants underwent an ERP recording during the 50 min. interval between immediate and delayed recall of a short story. ERPs elicited by pictures that either related to ("old"), or did not relate to ("new") the story were recorded using a 3-stimulus visual oddball paradigm. ERP old/new effects were examined at selected scalp regions of interest at three intervals post-stimulus: early (250-350 ms), middle (350-700 ms) and late (700-1100 ms). Attention-related ERP components (N1, P2, N2 and P3) evoked by story-relevant pictures, story-irrelevant pictures, and irrelevant distractors were measured from midline ERP electrodes. Differences in IS were reflected in late right prefrontal old/new differences, while differences in memory and task performance were reflected in early and middle latency old/new differences. Results supported an account of individual differences in IS as reflecting post-retrieval memory processes rather than attentional processes. In addition, it was shown that neurotic introverts tended to be more compliant.

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List of Abbreviations

ANOVA	Analysis of variance
C	**C**ondition in the three stimulus oddball paradigm in which there are three conditions, Condition1 (C1); geometric shape, Condition2 (C2); relevant-to-the-story/old pictures, and Condition3 (C3); irrelevant-to-the-story/new pictures
Ch	**Ch**annel; ERP electrode sites
CR	**C**orrect **R**ejection: story-irrelevant/new pictures correctly identified as such
De-Re, De-Recall	Delayed recall from the Gudjonsson Suggestibility Scale paradigm
DRM paradigm/questionnaire	The Deese, Mc-Dermott-Roediger paradigm/questionnaire
DRM-FA, FA-DRM	**F**alse **A**larm from the Deese, McDermott-Roediger paradigm; critical lures falsely recognized as old
FA (oddball), FA-oddball	**F**alse **A**larm from the oddball paradigm: story-irrelevant/new pictures incorrectly identified as story-relevant/old pictures
GCS	**G**udjonsson **C**ompliance **S**cale
GSS	**G**udjonsson **S**uggestibility **S**cale paradigm which have two versions, GSS1 and GSS2
Hit	Correct Recognition: story-relevant/old pictures correctly identified as such
Im-Re, Im-Recall	Immediate recall from the Gudjonsson Suggestibility Scale paradigm
IS	**I**nterrogative **S**uggestibility
Miss	Incorrect rejection: story-relevant/old pictures incorrectly identified as story-irrelevant/new

Mislead, Misleading	Misleading questions in the Post-Event Memory Questionnaire paradigm
MDS	**M**emory **D**istrust **S**yndrome
ms	**m**illi**s**econd
MTL	**M**edial **T**emporal **L**obe
N	Numbers of participants
New	Participants circled correctly “new” words as “new” in the DRM questionnaire.
New2	Participants circled correctly “new” words as “new” in the other form of the DRM questionnaire.
Old	Participants circled correctly “old” words as “old” in the DRM questionnaire.
Old2	Participants circled correctly “old” words as “old” in the other form of the DRM questionnaire.
PEMQ	The **P**ost-**E**vent **M**emory **Q**uestionnaire
Repeat	Repeated questions in the PEMQ paradigm
RT	**R**eaction **T**ime
RW, DRM-free recall	**R**ecall **W**ord, free recall from the DRM paradigm
SD	**S**tandard **D**eviation
SE	**S**tandard **E**rror
Shift	Participants shifted their answers after the negative feedback
Specific	Specific questions in the PEMQ paradigm
TS	**T**otal **S**uggestibility which is the sum of Yield1 and shift
Yield1	Participants yielded to the leading questions in the Gudjonsson Suggestibility Scale paradigm

Yield2	Participants yielded to the leading questions in the Gudjonsson Suggestibility Scale paradigm after the negative feedback
OF	Orbitofrontal region
FC	Fronto-central region
CP	Centro-parietal region
LPF	Left prefrontal region
RPF	Right prefrontal region
LTP	Left temporo-parietal region
RTP	Right temporo-parietal region

Preamble

False confessions can put innocent people to jail. There are various factors that influence accuracy in the process of confessions. One of these factors is the suggestive interviewing techniques. The suggestive interviewing techniques have a high risk of tainting individuals' testimony which has long been realized and accepted by courts of law. However, reliable information about the types of people who are most likely to be tainted by suggestive interviewing has not been established (Bruck & Melnyk, 2004). The correlations between suggestibility and psycho-social (e.g. self-concept, compliance) and cognitive (e.g. intelligence, memory) factors, as reviewed by Bruck and Melnyk (2004), are reported to be inconsistent. Some studies found significant correlations; others did not. Even worse, there were significant correlations in unexpected ways. Lee (2004) found that better verbal paired associates memory can be correlated with either higher or lower suggestibility depending on the paradigms used to measure suggestibility.

With the contradictions mentioned above, the present study would like to explore the relationship between interrogative suggestibility and memory/attention using ERPs (event-related potentials) to illustrate the ERP differences of low and high individuals of interrogative suggestibility measured by a well-accepted Gudjonssons Suggestibility scales (GSS). The exploration comprised two studies due to thesis development. Study 1 used the PEMQ paradigm (Post-Event Memory Questionnaire; Eisen, Morgan, & Mickes, 2002) to screen participants of supposed-to-be low and high suggestible individuals to participate in the GSS paradigm and the ERP measurement. However, from Study 1, there were a small number of participants to be analyzed for ERPs and the correlations of the misleading questions of the PEMQ paradigm and the Yield score of GSS scales were *less* positively correlated than the correlations of the false alarm to lure score of the DRM paradigm (DRM-FA; Deese-Roediger, McDermott list learning paradigm; Deese, 1959 and Roediger & McDermott, 1995) and the Yield score of GSS scales. Therefore, Study 2 was conducted using the DRM-FA instead of the misleading questions of the PEMQ paradigm to screen participants of supposed-to-be low and high suggestible individuals to participate in the GSS paradigm and the ERP measurement. For data analyses, due to the same procedures of ERP and GSS measurements except only for the preliminary screening process of participants, the two studies were collapsed and analyzed as one.

This thesis has been organized into 7 chapters. Chapter 1, Introduction, the involved literature, namely, Interrogative Suggestibility (IS), ERPs, memory, attention, and the linkages among the mentioned variables including research questions and hypotheses will be presented. Chapter 2, the methodology of the studies will be described, focusing on (i) cognitive/behavioural measures and (ii) ERP measures. This will be followed, in Chapter 3, by Result 1: Memory and Task Performance and, in Chapter 4, by Result 2: Some Personality correlates of IS. Chapter 5 will present results from the present study pertaining to memory, ERPs, and IS. Chapter 6 will present results from the present study pertaining to attention, ERPs and IS. Finally, Chapter 7 will present an overall discussion of the results.

It was hoped that findings from the present study might shed some light on the brain mechanisms that produce individual differences in Interrogative Suggestibility. Such knowledge would give us a better understanding of not just *who*, but more importantly *why*, some people are likely to give false confessions which are still a major issue in legal contexts.

Chapter 1

Introduction

Prologue:

This chapter offers reviews of findings related to interrogative suggestibility (IS), EEG (Electroencephalogram), ERPs (Event-Related Potentials), memory and attention followed by a statement of research questions and hypotheses addressed in this thesis. Since the importance of IS in legal/forensic contexts lies in its relationship to false confessions, this review will start with an outline of findings related to confessions in a legal context.

Confessions

Confessions are crucial processes in the legal system. Many studies have been conducted to find out why people confess (e.g. Gudjonsson & Sigurdsson, 1999; Gudjonsson & Petursson, 1991). There are many factors that are related to proneness to confess. Suspects confess due to a combination of factors, rather than to one factor (Gudjonsson, 2003). However, some suspects confess to a crime that they are really innocent of, which is called “false confession”. False confessions are important because they can lead to wrongful convictions. As a result, innocent people are punished for a crime they have not committed. False confessions can occur frequently and are difficult to detect (Gudjonsson & Sigurdsson, 1994).

Gudjonsson and Sigurdsson (1994) conducted a study to see how frequently false confessions occur. He found that female prisoners claimed to have made more false confessions than males. The reasons for making false confessions were to protect someone else from being prosecuted (48%) or because of police pressure or to avoid a prison sentence (52%). Most of them (78%) had never retracted the confession, stating that they had seen no point to do so. In addition, the majority of them (78%) were convicted of the crime to which they had made a false confession.

Definitions of false confession

Ayling (1984) suggests that there are two ways of defining false confession. Firstly, there are cases where the persons are totally innocent. They have not known anything about the crime. Secondly, there are cases where the persons overstate their involvement in the crime. Ayling (1984) suggests that overstating involvement in the crime is much more common than confessing to a crime that the individual is not involved in at all; however, he does not provide data to support his claim.

Different types of false confessions

There are many causes of false confession. Kassin and Wrightsman (1985) defined three types of false confession. Firstly, voluntary false confession where the false confession is offered voluntarily by an individual, without police pressure. According to Kassin and Wrightsman (1985), this may be due to a pathological need to become infamous, an unconscious need to relieve guilt via self-punishment, inability to distinguish facts from fantasy, or a desire to protect the real offender, and so on. Secondly, coerced-compliant false confession which results from the pressure or coerciveness of the interrogation process; for example, the confessor may want to escape from the interrogation, bringing the interview to an end. Thirdly, coerced-internalized false confession which occurs when suspects come to believe that they have committed the crime, although they have no actual memory of the crime. Gudjonsson (2003) invoked IS as the cause of this kind of false confession. Gudjonsson and MacKeith (1982, cited in Gudjonsson, 2003) further stated that this kind of confession came from a Memory Distrust Syndrome (MDS) which they defined as "a condition where people develop profound distrust of their memory recollections, as a result of which they are particularly susceptible to relying on external cues and suggestions (p.196)".

Gudjonsson (2003) stated that there were two types of MDS. Firstly, it may result from amnesia or alcohol induced memory problem. Secondly, suspects may, at the beginning of the police interview, have a clear recollection of not having committed the offence, but later come to distrust their recollections as a result of subtle interrogation.

As stated by Gudjonsson (2003), a phenomenon that causes false confessions, particularly of the coerced-internalized type, is Interrogative Suggestibility (IS).

The definition of IS

The idea of IS has its origin in the work of the French psychologist Binet, who some 75 years before the phenomenon of false memories was re-discovered, described a series of studies in which he manipulated, and measured IS in school children (Binet, 1900). Binet described two types of memory errors: logical errors, and errors of the imagination. According to Binet, errors of the imagination arise when individuals construct an object that is not real. Garry, Manning, Loftus, and Sherman (1996) referred to this confidence-inflating effect of the imagination as "imagination inflation". Later, Powers, Andriks, and Loftus (1979) defined IS as "… the extent to which they (people) come to accept a piece of post-event information and incorporate it into their recollection (p.339)". According to Gudjonsson (2003), this definition is too vague and it has not been proven whether or not the individual incorporated the suggested information into their recollection, even though they seemed to accept it. Gudjonsson and Clark (1986) provided the following, more focused definition:

"The extent to which, within a closed social interaction, people come to accept messages communicated during formal questioning, as the result of which their subsequent behavioural response is affected (p.84)".

Gudjonsson (2003) states that this definition comprises five interrelated components of IS process which are:

1. a social interaction
2. a questioning procedure
3. a suggestive stimulus
4. acceptance of the stimulus
5. a behavioural response, such as a verbal reply to the question asked.

In police interviews, the interview is a closed social interaction, involving the interviewer and the interviewee. Interruptions are avoided as much as possible (Irving, 1980 cited in Gudjonsson, 2003). This means that the police interview process can easily induce suggestibility through the use of coercive interviewing techniques on the part of the interviewer. As a result, vulnerable individuals may be susceptible to IS.

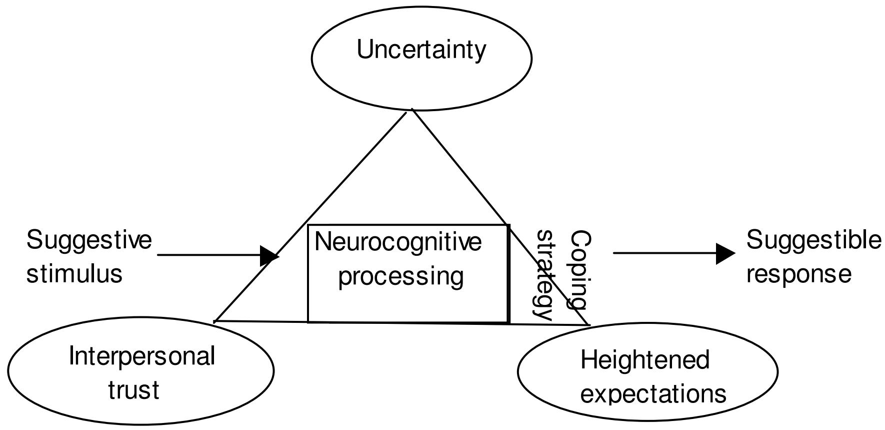
While Binet's pioneering studies focused on both inter-individual variation in IS (the "Who?" question) as well as on the possible underlying mechanisms (the "How?" question), subsequent research has tended to focus on one or the other. An individual differences approach has been adopted by Gudjonsson and others (see Gudjonsson, 2003, for a review), while an experimental approach has been pursued in the U.S. by Loftus and her colleagues (reviewed in Gerrie, Garry, and Loftus, 2004). The latter has principally been concerned with the conditions under which leading questions are likely to affect the verbal accounts of witnesses. They have concluded that Interrogative Suggestibility is mediated by a central cognitive mechanism, a lack of "discrepancy detection" which is the ability to detect the discrepancy between the event information and the post event information (e.g. leading questions).

The individual differences approach to IS:

The Gudjonsson-Clark Theoretical model

A theoretical model of IS was described by Gudjonsson and Clark (1986). The model integrates the leading questions and the negative feedback aspects of IS. The basic assumption of the model is that IS depends on the coping strategies that people use when they are faced with two major aspects of the interview situation, namely, uncertainty and heightened expectations. The model begins by social situation in which the interviewee adopting a general cognitive strategy to deal with it. A general cognitive strategy can facilitate either suggestible or resistant response. Once the police begin to ask questions, the interviewee has to deal with *uncertainty* and *interpersonal trust* on one hand and *expectations* on the other. Then, the interviewee develops a cognitive appraisal that results in a coping strategy, following which either a suggestible or a resistant response will ensue (see Figure 1). An avoidant coping strategy will result in a suggestible response, comprising a Yield response (yielding to the suggestive stimulus) and/or a Shift response (shifting one's answer under interrogative pressure; for example, when given negative feedback, "That's not true!").

Figure 1 A theoretical model of interrogative suggestibility



In sum, the following three components are viewed as essential prerequisites to the process of IS as follows.

1. Uncertainty

The interviewee is not sure of the correct answer to the question being asked. Then, s/he may accept the leading question as a correct answer. Some interviewees may go along with a leading question even if they know it is wrong in order to please the interviewer. In this case, they are showing compliance rather than suggestibility.

2. Interpersonal trust

The interviewee believes that the interviewer's intentions are constructive, genuine, and that no trickery is involved. The interviewee's suspiciousness is likely to reduce his/her susceptibility to suggestions.

3. Expectation

This refers to the interviewee being reluctant to declare his/her uncertainty and lack of knowledge because s/he believes that s/he should know the answer or is expected to know the answer.

According to Gudjonsson and Clark (1986), apart from uncertainty, interpersonal trust, and expectation which are essential prerequisites for the suggestibility process, feedback is also an important part of IS. Gudjonsson and Clark (1986) defined feedback as "a signal communicated by an interrogator to a witness, after s/he has responded to a question or a series of questions, intended to strengthen or modify subsequent responses of the witness (pp. 93-94)".

Adding to the Gudjonsson-Clark Theoretical model: Discrepancy detection

Schooler and Loftus (1986) proposed that the model could be enriched by considering "discrepancy detection". According to Schooler and Loftus (1986), "Recollections are most likely to change if a person does not immediately detect discrepancies between post-event suggestions and memory of the original event (pp.107-108)". This helps to explain the process whereby people accept and integrate inconsistent information into their memories~~,~~ (Tousignant, Hall, & Loftus, 1986).

People tend to remember central details better than peripheral details (Wright & Stroud, 1998). As a result, memory for peripheral details should be more affected by misleading post- event information than memory for central details (Gerrie, Garry, & Loftus, 2004). Gerrie et al. (2004) further state that memory strength is directly related to how much attention people pay to an event and, as memories fade, suggestion is more likely to occur.

The Gudjonsson-Clark theoretical model together with discrepancy detection contribute to an understanding of why some people tend to be suggestible. However, suggestibility is not the only element to give rise to distorted or false confessions. Other evidence has also to be explored to understand the process of false confession. In addition, suggestibility also plays an important role in psychotherapy. Hypnosis that some therapists use to heal clients to unravel unconscious experiences is involved in a kind of suggestibility.

Different types of Suggestibility

Suggestibility is a person's propensity to respond to suggestion or suggested communications without critical thinking. Eysenck, Arnold, and Meili (1975) refer to suggestibility as "the individual degree of susceptibility to influence by suggestion and hypnosis (p.1076)".

Bruck and Melnyk (2004) defined four components of suggestibility as follows.

1. Interrogative Suggestibility which is the degree that one agrees with misinformation or misleading questions about a target event. In the interrogative suggestibility paradigm, suggestions are administered at test and two types of suggestions are used, misleading questions and critical feedback.

2. Misinformation effects which are the incorporation of false information into subsequent reports about a target event. In the misinformation paradigm, suggestions/misinformation are embedded into the subsidiary clauses of subsequent questions with no explicit instructions on their truth value and administered between initial exposure to the witnessed event and the final retrieval test.

Loftus, Miller, and Burns (1978) used the "misinformation effect" paradigm to show that questions or statements occurring after an event can alter eyewitness accounts.

The standard misinformation effect paradigm is a three-step procedure. First, participants experience an event (e.g. an automobile accident resulting from a car that failed to yield the right of way and caused collision). Second, participants receive misleading information regarding that event; for example, participants are later asked a series of questions about the event (e.g. “Did the car pass the red Datsun while it was stopped at the stop sign?”). These questions provide information in which misinformation is embedded. Then, there is some delay (e.g. participants complete a task unrelated to the experiment). Third, a memory test of the original event is given; for example, by asking questions (e.g. “Was there a stop or a yield sign?”). Results show that participants who are given the misinformation report more erroneous answers.

3. Source misattribution which is the inability to differentiate between suggestive and actually occurred details about a target event. This measure serves as an indication of whether the misinformation effect reflects false beliefs.

4. False event creation which is the construction of a narrative of an event that did not take place through suggestive techniques.

The paradigms that are commonly used for studying false memory are the Interrogative Suggestibility paradigm developed by Gudjonsson and the misinformation effect paradigm developed by Loftus and her colleagues. Schooler and Loftus (1986) suggested that the two approaches should be viewed as complementary, not competitive or mutually exclusive. Future research needs to clarify the relationships among various forms of suggestibility (Destun & Kuiper, 1996).

Features of IS that distinguish it from other types of suggestibility

According to Gudjonsson (1989), the features that distinguish IS from other types are:

1. IS involves a questioning procedure which takes place within a social interaction.

2. The questions asked are concerned with past experiences, events, and recollections, whereas other types of suggestibility are concerned with the motor and sensory experiences of the immediate situation.

3. IS contains a component of uncertainty, which affects the ability of the person to process information.

4. Questioning in the police interview usually involves a high degree of stress with important consequences for the witness, victim and suspect.

The measurement of IS

Gudjonsson developed scales (the Gudjonsson Suggestibility Scales, GSS) that measure IS, for both clinical and research purposes. His scales followed the early work and research of Binet (1900), Stern (1910), and Loftus (1979). The main clinical/forensic purpose of the scales was to help identify people who are susceptible to giving erroneous accounts of events when subjected to leading questions, whereas the main research interest was to investigate the process and mechanism of IS and the factors associated with it. There are two scales of IS, GSS1 and GSS2 which are claimed to be parallel to each other and to produce similar norms and correlations (Gudjonsson, 1997).

Both GSS1 and GSS2 employed the same format, administration and scoring criteria to measure IS. The only difference between GSS1 and GSS2 is the content of the narrative stories and interrogative questions. GSS1 is a story about a female tourist who is robbed by three men in front of her hotel in Spain, whereas GSS2 is a story of a young boy who is riding his bicycle down a slope and suddenly his brakes fail and he cries for help (see Appendix A). Both GSS1 and GSS2 produce measures of the Yield and Shift components of IS, and a total score comprising the sum of these two components.

The Gudjonsson Compliance Scale (GCS)

Gudjonsson constructed the GCS to complement the theoretical and empirical work of IS. He states that at a theoretical level, compliance differs from suggestibility in that it does not require a private acceptance of the request. In other words, some individuals comply with requests and obey instructions for instrumental gain, although they do not agree with the request; for example, to terminate the police interview, to be released from custody quickly, to escape from the stressful situation, or to please the interviewer and so on (Gudjonsson, 1997).

Alleged false confessors who had retracted a confession previously made to the police had the highest scores of the GCS, whereas resisters who had been able to resist police interrogation had the lowest scores of the GCS (Gudjonsson, 1997).

Gudjonsson (1997) further states that the conceptual basis of GCS relates closely to Milgram's (1974) studies on obedience. Milgram defined obedience as the action of a subject "who complies with authority (p.113)". He investigated how far subjects could be manipulated to obey instructions that would ordinarily be unreasonable and unacceptable. His research focused on how experimental subjects reacted to pressure from a person in authority. It differs from Asch (1954)'s experiment regarding conformity and group pressure where the pressure was indirect and the subjects were unaware of the pressure that influenced them.

Gudjonsson (1989) theorized that compliance was due to two related factors which are: (1) an eagerness to please and the need to protect one's self-esteem in social interactions; (2) the avoidance of conflict and confrontation in the company of people in authority. When one or both factors are prominent, people may be likely to comply with requests or obey instructions that they normally reject. This is also consistent with the findings from Milgram's (1974) experiment.

Gudjonsson states that IS and compliance at the conceptual level are overlapping constructs that share similar mediating variables such as avoidance of conflict and confrontation and eagerness to please, which would theoretically relate to how the person tends to cope with leading questions and interrogative pressure.

Gudjonsson (1997) stated that another basis of the construction of the GCS was to measure the susceptibility of individuals to being coerced or led into criminal activity by a more forceful compliance. This may make some persons susceptible to exploitation by another. Compliance can be measured by either direct observation of behaviour or self-report (see Appendix B for a self-report form which was used in the present study).

As for the correlations between IS and some variables reviewed by Bruck and Melnyk (2004), findings of relationships are sometimes inconsistent and sometimes depend on measures of suggestibility used (e.g. Lee, 2004). However, relationships between IS and some important variables could be summarized as follows:

Correlations between IS and memory

Major research regarding IS and memory is reviewed as follows.

Gudjonsson (1987) conducted a study to investigate correlations between memory and IS both within and between (GSS1 & GSS2) tests. He found that the correlations were very similar for the within and between measures. The findings indicate that IS correlates negatively with individuals' memory capacity. Correlations of memory and suggestibility are typically between –0.5 and –0.6 in normal subjects and are considerably lower among forensic patients than normal subjects (Gudjonsson, 1988a). Polczyk (2005) also found negative correlations between IS & GSS memory recall, including IS & intelligence.

Gudjonsson and Singh (1984) found that memory recall of the GSS1 correlated negatively with observers' independent ratings of IS. Gudjonsson (1983) also found that the more rapidly memory deteriorated over a 40-50 minute period, the more suggestible normal subjects were likely to be. Gudjonsson reasoned that people whose memory decays rapidly over time learn to distrust their own memory and rely more on cues provided by other people. According to Gudjonsson (2003), such people in extreme cases suffer from a "memory distrust syndrome (MDS)".

Pezdek and Roe (1995) found that if children's memory was tested for an event that occurred to them frequently, they would have more accurate memory for the event and be less suggestive, when compared to an event occurred only a single time.

Liebman et al. (2004) used two paradigms of suggestibility, the Gudjonsson Suggestibility paradigm (GSS2) and the misinformation effect paradigm to study cognitive and psychosocial correlates of suggestibility. They found that more suggestible individuals had poorer recall of memory on both suggestible measures.

Schacter (1999) also specified suggestibility as one of the seven sins of memory: transience, absent-minded, blocking, misattribution, suggestibility, bias and persistence.

However, Lee (2004) found that participants with higher scores on the verbal paired associates task from the Children's Memory scale were less suggestible when the GSS2 was used, but more suggestible when the misinformation effect paradigm was used. He suggested that "better mnemonic function can be associated with either higher or lower suggestibility depending on the way in which participants are misled (p.1014)". He further stated that this may be because two paradigms are quite different in many aspects (e.g. form of the original stimuli, the retention interval between a target event and a retrieval test, the timing when suggestions are administered, type of memory questions, etc.) which can vary the magnitude of the misinformation effect and that better mnemonic abilities do not always predict suggestibility. In addition, Bruck and Melnyk (2004) reviewed literature and found that traditional memory tests did not always correlate with measures of suggestibility. The relationships may be task specific - memory of one event was not correlated with suggestibility in a second event. He suggested that the negative correlations between memory and suggestibility found in many studies reflect context-specific factors rather than cognitive ability of individual children.

In sum, much research, especially when an event and memory for that event was measured, found that memory capacity plays a crucial role in the degree of suggestibility. Individuals who are susceptible to suggestibility tend to have lower memory capacity. However, the context-specific factors of correlations between suggestibility and memory for the GSS paradigm (Bruck & Melnyk, 2004) as well as different outcomes for different suggestibility paradigm (Lee, 2004) show that further studies or methods are required to explore the association between memory and suggestibility and to precisely differentiate low and high suggestible individuals.

IS and attention

Studies regarding IS and attention have been little explored. However, some researchers (Gerlie et al., 2004; Howard & Ng, 2002) stated that suggestible individuals should have divided attention. The "misinformation effect" described by Loftus and colleagues, the ability to detect discrepancies between an event and misleading post-event information, is said to be a function of both memory for the event and the amount of attention paid to the misleading information. Diffused or unfocused attention makes some people to be easily distracted or suggestible. This may be because they are not sure about their own memory and have to rely on the external cues. Memory and attention are intercorrelated, not mutually exclusive.

IS, compliance, and acquiescence

The evidence reviewed by Gudjonsson (2003) indicates that Interrogative Suggestibility and compliance are overlapping characteristics that share similar mediating variables. There is a weak but significant correlation between IS and acquiescence**,** which is the tendency to answer questions in the affirmative regardless of their content. However, the correlation between IS and acquiescence may not be found in all studies. There is no significant relationship between compliance and acquiescence.

IS and personality

Muris, Meester, and Merckelbach (2004), in a study of delinquent adolescents, did not find significant correlations between IS and personality characteristics, such as social inadequacy, social desirability, and fantasy proneness. Polczyk (2005) also found no correlations between IS measures from GSS1 and any of the Big Five from Costa and McCrae's (1992) Five Factor Model (GSS2 was not administered along with personality variables); however, he found positive correlations between IS & social desirability, and IS & vividness of imagery. Gudjonsson (2003) concluded that IS and compliance correlated with social desirability, but the correlation was small and not significant in all studies.

In contrast, Hook and Steele (2002) found that susceptibility to suggestive information, assessed by Lindberg's suggestibility measure (Lindberg, 1991) appeared to differ across personality variables using Millon Index of Personality (Millon, 1994) such as sensing, innovating, agreeing, and low tolerance of ambiguity using AT-20 (MacDonald, 1970). Liebman et al. (2004) found that suggestibility on the GSS2 correlated negatively with locus of control, extraversion, and conscientiousness as measured by Revised NEO Personality Inventory (NEO PI-R; Costa & McCrae, 1992) and Multidimension Personality Questionnaire (MPQ; Telegen, 1982, cited in Liebman et al., 2002). In contrast, suggestibility on the misinformation effect paradigm correlated positively with openness to experience and agreeableness as measured by NEO PI-R. They suggested that it seems to have many forms of suggestibility.

IS and gender

Powers, Andriks, and Loftus (1979) found that females were significantly more suggestible than males. They also found that sex differences in accuracy were related to the type of questions being asked. Females were significantly more accurate than males on questions dealing with female-oriented details (e.g. woman's clothing and actions), whereas males were more accurate when the male-oriented details were asked about (e.g. the thief's appearance and the offence's surroundings). They concluded that each sex pays more attention to items that are related to their interests and most relevant to their own sex. However, Redlich (1999, cited in Gudjonsson, 1997) found that males were significantly more suggestible than females. However, different suggestibility paradigms were used in these studies: the misinformation effect paradigm by Powers et al. vs. the Gudjonsson paradigm by Redlich.

Bruck and Melnyk (2004) reviewed the literature and concluded that there were no consistent gender differences in children's suggestibility and suggested that "it is recommended that gender be included as a factor in the analysis of suggestibility studies only if there is a primary theoretical motivation for its inclusion (p.986)".

IS and ethnic background

Gudjonsson, Rutter, and Clare (1995) found that Afro-Caribbean police detainees scored significantly higher than their Caucasian counterparts on all the GSS2 suggestibility measures but there was no IQ difference between both groups.

IS and age

Gudjonsson (2003) showed that younger children are more suggestible than older children, in terms of yielding to leading questions (Yield1) and interrogative pressure

(Shift). However, children who are 12 years old or older perform similarly to adults, but they do not cope as well as adults with interrogative pressure. He concluded that interrogative pressure can be an important consideration in the police interviewing of children and juveniles.

IS and intelligence

Gudjonsson and Clark (1986) suggested two reasons why negative correlations between intelligence and IS should be found. First, IS is related to uncertainty which depends on an individual's memory capacity, and memory is correlated with intelligence to some extent. Second, IS is influenced by the person's ability to cope with the uncertainty, expectations, and pressure associated with interrogation. Therefore, persons who have low intelligence would have more limited intellectual resources to help them to cope with an unfamiliar task, such as interrogation.

However, some studies did not find such negative correlations. For example, Gudjonsson (1988a) found that IQs above 100 in normal subjects and forensic patients did not correlate significantly with IS, whereas IQs below 100 as well as the entire IQ range correlated significantly with IS. Tata (1983 cited in Gudjonsson, 2003) also did not find significant correlation between IQ and IS scores on GSS1, with the range of IQ scores falling between 106 and 125.

Gudjonsson (2003) concluded thus: "suggestibility is mediated and affected by a range of factors, rather than one factor alone. Intellectual functioning is only one of several factors that are likely to mediate suggestibility and its overall influence may be comparatively modest (p.384)".

IS and creativity

As reviewed by Bruck and Melnyk (2004), imaginative and creative children were more likely to be suggestible and to elaborate false beliefs. Positive correlations were found in all of the studies of all measures of suggestibility.

IS and anxiety

Gudjonsson (1988b) found that Interrogative Suggestibility is strongly and positively associated with state anxiety. State anxiety is most clearly associated with how subjects react to interrogative pressure rather than to leading question alone. Tata (1983 cited in Gudjonsson, 2003) also found that negative feedback on the GSS1 is accompanied by increased electrodermal activity and mood changes as measured by the Multiple Affect Adjective Checklist (Zuckerman & Lubin, 1965). In addition, as reviewed by Bruck and Melnyk (2004), children in a high-stress group were more suggestible than children in a low-stress group and children in a sad mood were more suggestible than children in an angry or happy mood.

IS and self-esteem

Studies have found a negative correlation between self-esteem and IS. The results indicate that feeling of powerlessness and incompetence are effective in inducing IS (Gudjonsson, 2003).

IS and previous convictions

Gudjonsson and Singh (1984) found that the extent to which delinquent boys resist interrogative pressure during interrogation is significantly correlated with their previous convictions. They stated that there are at least two reasons why criminals with previous convictions should be less suggestible than those with no previous convictions.

First, offenders with extensive experience of police interrogation may develop increased resistance to interpersonal pressure. Second, criminal recidivists may characteristically tend to resist interpersonal pressure more than less habitual offenders.

IS and false confessions

Sigurdsson and Gudjonsson (1996) found that false confessors were more anxious and personality disordered than true confessors and they had significantly higher mean GCS scores. Furthermore, Redlich (1999 cited in Gudjonsson, 2003) studied the relationship between false confessions and IS among young persons. He found that there were relationships between Yield scores, TS scores, and making false confessions. Both studies mentioned above found a relationship between false confessions, particularly of the coerced-internalized type and IS. This means the suspects come to believe during the police interview that they have committed the crime, although they have no actual memory of having committed the crime.

Next, another main focus of this thesis, event-related potentials (ERPs) will be reviewed.

EEG and ERPs

The EEG (electroencephalogram) is the record of the tiny fluctuations in voltage that can be recorded from the scalp and displayed, either on paper or on an oscilloscope screen, as a spatio-temporal pattern. Its history dates back to Berger (1929, cited in Fabiani, Gratton, & Coles , 2000) who first demonstrated the possibility of recording these fluctuating changes in voltage, the spontaneous neuronal rhythms of various frequencies, by placing electrodes on the surface of the scalp in human subjects. With the advent of the digital computer in the 1950s, it became possible for these EEG signals to be digitized and averaged, permitting the recording of event-related EEG activity (i.e. activity that is time-locked to a discrete event). Such event-related EEG activity is referred to as brain event-related potentials (ERPs, see Figure 2). Through signal averaging (i.e. summing of activity that is time-locked to a discrete event), it became possible to distinguish the brain's response when an individual processes and responds to an event, from the brain's spontaneously occurring rhythms (which are regarded as "noise") and artifacts of various sorts (Cooper, Osselton, & Shaw, 1980).

It is assumed that ERPs are the distal integration of neuronal activities. Only a subset of the entire brain electrical activities can be recorded from scalp electrodes. This is because the neurons must be active synchronously and the electrical fields generated by each particular neuron must be oriented in such a way that voltages can be summated (Fabiani, Gratton, & Coles , 2000). Since the origins of the electrical activities that the brain generates cannot be pinpointed easily and the ERPs can be the integration of electrical activities from many millions of neurons, the interpretation of ERPs has to be carried out with caution. Much research has been carried out to explore the relationship between ERPs, physiological and psychological processes; however, the results are not well-established, and ERP research still has a long way to go. There are two fundamental approaches to the study of ERPs: "Top-down" and "Bottom-up". The former starts from cognition and behavior, and attempts to map cognitive/behavioural processes onto ERP components. For example, in regard to memory it starts from dual process theory and attempts to map distinct processes of familiarity and recollection onto spatio-temporal aspects of ERPs. The "bottom-up" approach, in contrast, attempts to delineate the neural generators of ERPs, and attempts to solve the inverse problem.

ERPs are obtained by averaging EEG patterns recorded over as many as 100 trials where a trial constitutes a single occurrence of the event or stimulus (Kutas & Hillyard, 1980). The number of trials averaged depends on the particular ERP component being measured. Small ERPs like the brainstem auditory evoked potential (3 or 4 microvolts) require the averaging of many trials (hundreds) so that the signal-to-noise ratio can be enhanced sufficiently to make them visible and measurable (since they are swamped by the background EEG rhythms). Larger ERPs like P3 (10-20 microvolts), because they stand out from the background EEG more prominently, require fewer trials (16-20) to form an average ERP that is measurable. Choice of the number of trials is a trade-off between having an adequate signal-to-noise ratio, on the one hand, and keeping the duration of the recording to a minimum, on the other hand, to prevent participants fatigue and habituation of the ERP. However, P300 amplitude and latency generally stabilize with approximately 20 trials (Cohen & Polich, 1997).

One of the problems associated with ERP recording is that of artifacts, which will be reviewed next.

Artifacts

Any movement of muscles such as those in the eyes or limbs also produces electrical activities. As such, event-related potentials are contaminated easily by these movement related electrical activities. In any ERP experiment, it is crucial to ensure that participants sit still and fix their eyes on the cross at the centre of the screen to reduce extraneous electrical activities. The average of the ERPs across participants which is called the “grand average” can eliminate artifacts to some extent. The ERP analysis program used in the current research has the eye correction program that detects and calculates mathematical models to subtract eye blinking and eye movement from the brain wave. In addition, it also has the artifact correction program to detect other signal artifacts.

Peak and Latency measurement

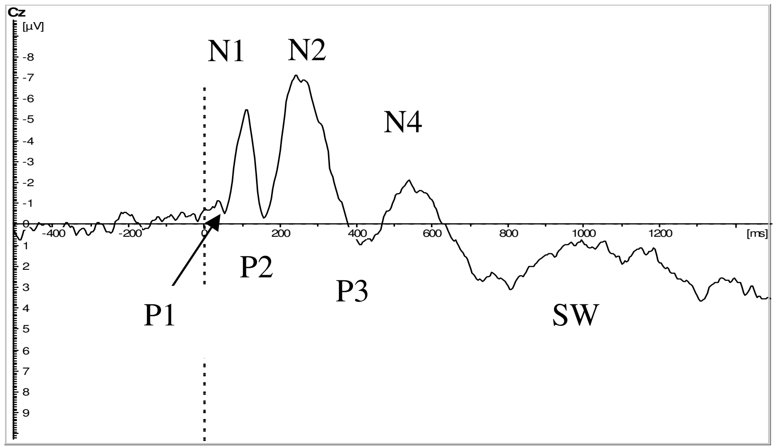
The electrical fields of ERPs synchronize into positive and negative peak components (P means the positive peak, N means the negative peak). Each peak has the maximum amplitude which is customary to be measured from pre stimulus baseline to the peak of ERPs at each epoch. Each peak has its own latency (i.e. a period of time after the stimulus onset when that peak appears maximally). It is believed that peaks and latencies are related to physiological and psychological processes.

Altogether, ERPs can be classified into two main classes of components (Fabiani, Gratton, & Coles, 2000). Firstly, sensory or exogenous components which mostly reflect the physical properties of an external event. Secondly, endogenous components, which are determined more by the nature of the interaction between the subject and the event which is related to psychological processes. Endogenous components usually occur later, from 100 ms after stimulus onset. Some ERPs can be sensitive to both physical stimuli and subject-event interaction. These ERPs are called mesogenous ERPs (e.g. N1).

ERP components

ERP components are named according to their approximately elicited time, order of their peaks or their appearance. The traditional way of displaying polarity of ERPs is negative up and positive down, as in Figure 2.

Figure 2 ERP main components



The main mesogenous or endogenous components will be briefly reviewed with reference to the psychological processes associated with them.

<u>P100 or P1 / N100 or N1</u>

P1 and N1 appear around 100 ms after stimulus onset. The general findings show that stimuli falling within the spotlight of spatial attention elicit enhanced P1 (80-120 ms) and N1 (160-200 ms) over posterior regions (Mangun & Hillyard, 1995).

<u>N200, N2</u>

N2 appears about 200 ms after stimulus onset. The amplitude of N2 appears to reflect detection of the mismatch between the stimulus and the previously formed template (Fabiani, Gratton, & Coles, 2000). In addition, Gehring, Gratton, Coles, and Donchin (1992) used a two-stimulus visual paradigm in which the first stimulus provided the information regarding the second stimulus to be presented. They observed a larger N2 to the second stimulus at frontal sites when the features of the second stimulus were mismatched with the subject's expectation.

P200, P2

P2 appears around 200 ms after stimulus onset. Research has shown that the P2 to standard stimuli may appear larger in attend than ignore conditions (Naatanen & Gaillard, 1983).

P300, P3

P3 is a late positive complex which comprises a family of positive components, P3a and P3b. In the present study, the three stimulus oddball paradigm was used and P3b was of the main focus of the present study. However, in the present study, every ERP graph has one prominent P3 peak and labeled as "P3".

The classic P300 or P3b

P3 appears around 300 ms after stimulus onset. The classic P300 or P3b is elicited by task-relevant, so-called "oddball" stimuli that occur against a backdrop of frequently occurring "standard" stimuli. It is maximal at posterior (parietal) scalp locations. The research conducted so far suggests that P300 may result from the summation of activity from various generators located in cortical and subcortical areas (Halgren et al., 1980; Johnson, 1993). Duncan-Johnson and Donchin (1977) reported that P300 amplitude was sensitive to stimulus probability: the lower the stimulus probability, the bigger the P300 amplitude. The stimuli must be relevant to the subject's task. If the events occur while the subject is performing another task, then even rare events do not elicit a P300 component. Kutas, McCarthy, and Donchin (1977) found that the latency of the P300 peak became progressively longer as the discrimination between the task conditions was made more difficult.

The frontal P3 or P3a

Courchesne, Hillyard, and Galambos (1975) used a modified oddball task in which unrecognizable complex stimuli were unexpectedly interspersed within the oddball sequence. They found that the unexpected novel stimuli elicited a positivity with a latency similar to that of the classic P300 except with a more frontally oriented scalp distribution. Since then, a number of studies have confirmed that a frontally oriented P3 is elicited by deviant stimuli that are rare, unexpected and having no previously formed memory template, in other words, novel stimuli. As a result, this frontal P3 has also been called “novelty P3”.

The relationship between the frontal and parietal P300 has been debated. Fabiani and Friedman (1995) have shown that all attended deviant items elicit frontal P3 when the stimuli are first presented. However, with subsequent repetitions of the same stimuli, the P3 backslides to a parietal maximum, which is typical for the classic P3 in young adult subjects. However, older adult subjects generate a frontally focused P3 even in response to deviant stimuli that are repeated a number of times. According to Fabiani and Friedman, this may be due to older subjects having problems forming or maintaining the stimulus template and consequently exhibit a frontal P3 even in response to repeated stimuli.

Regarding memory, Paller, Kutas, and Mayes (1987) recorded ERPs in an incidental memory paradigm. Subjects were asked to make either a semantic or a non-semantic decision and were subsequently and unexpectedly tested for their recognition or recall of the stimuli. They found that ERPs elicited during the decision task were predictive of subsequent memory performance, being more positive for words subsequently recalled or recognized than for words not recalled or recognized.

N400, N4

In general, N4 is believed to be a component associated with language operation. Kutas and Hillyard (1980) used a task in which subjects read sentences silently in order to answer questions about the content of the sentences later in the experiment. Some of the sentences ended with a semantically incongruous word. These incongruous words elicited an N4 component that was larger than that elicited by words that were congruous with respect to the meaning of the sentence. In addition, Chung et al. (1996) found that N4 is responsive to deviations from an affective frame of reference; for example, good outcomes in the context of common negative affect, as well as bad outcomes in the context of common positive affect. Therefore, it would be predicted that a similar N4 would be evoked by deviations from a motoric frame of reference. For example, when one is exerting pressure on the pedals of a bicycle, suddenly the chain comes adrift from its moorings. The rider experiences an immediate mismatch between the expected kinesthetic reafference and the obtained reafference. The motoric frame of reference is broken. As a result, an N400 should be elicited (Howard, 2001).

Slow Wave (SW)

Some parts of the ERPs do not have a specific peak, hence they have been named as slow waves according to their appearance. There are negative slow waves and positive slow waves which typically are slow steady shifts in potential, either positive or negative, from baseline.

The Contingent Negative Variation (CNV) discovered by Walter, Cooper, Aldridge, McCallum, and Winter (1964) is a slow negative wave that develops between two stimuli when a subject realizes the association between the stimuli and begins to expect the second stimulus after the first stimulus presented. Walter and colleaques (1964) called this an “expectancy wave”.

The Bereitschaftspotential first described by Kornhuber and Deecke (1965, cited in Feige, et al., 1997) is a slow negative wave that develops before a motor response and is associated with motor readiness, hence the term “readiness potential” has been applied to it.

The Processing Negativity (PN) is a negative wave that is generated when attention leads to further processing. This PN began at 150 ms and persisted until at least 500 ms. In auditory attention, Arthur, Lewis, Medvick, and Flynn (1991) found that the enlarged negative ERP elicited by attended stimuli included a processing negativity which originated from auditory cortex and persisted for several hundred milliseconds.

Mismatch negativity (MMN)

The MMN is a fronto-central negativity usually elicited at 100-200 ms after stimulus onset. It is elicited in response to discriminable auditory change; for example, frequency, intensity, or duration. However, the MMN to visual stimulus change is still unclear (Naatanen & Alho, 1995). The MMN is the difference wave resulting from the subtraction of the standard tone ERPs from the deviant tone ERPs and it is generated mainly in auditory cortex (Naatanen & Alho, 1995).

Next, an overview of memory including memory & ERPs and an overview of attention, including attention & ERPs will be discussed.

Overview of Memory

A brief, thumbnail sketch will be drawn of some important conceptual distinctions between different types and processes of memory. Recent ERP studies that have looked at ERP correlates of encoding and retrieval will then be reviewed. *Particular attention will be paid to ERP correlates of recognition memory within the two-process (or dual process) model of recognition memory, and an influential recent model, Mecklinger's (2000) neurocognitive model of recognition memory because recognition retrieval and ERPs are the main interest of the present study.*

Several models of memory have been proposed. Among these models, a two-store model of memory or "the modal model" (Atkinson, 1999) which was introduced by Atkinson and Shiffrin (1968) is the most influential. According to this model, memory comprises sensory memory and two stores, short-term and long-term memory. Sensory memory reflects the trace of a stimulus immediately after perceiving it. This sensory trace is involved in perception of the world and to store information from one frame until the arrival of the next frame in order to see a continuous moving image (Atkinson, 1999).

Short-term memory refers to the ability to maintain and manipulate active representations; for example, remember a phone number before dialing it. At first, short-term memory was considered as a unitary system. Its function is to maintain information and transfer it to long-term memory. Later on, many studies supported a variety of functions of short-term memory. As a result, Baddeley and Hitch (1974) proposed the multiple-components model of working memory, which comprises three components: (1) the phonological loop which processes phonological information; (2) the visuospatial sketchpad which processes visual and spatial information; and (3) the central executive which supervises and coordinates the two components.

Long-term memory comprises two broad categories of memory, explicit or declarative (aware) memory and implicit or nondeclarative (unaware) memory. Explicit memory refers to conscious recollections or remembrances, whereas implicit memory does not require conscious access. Tests of explicit memory, such as recognition and recall, depend on the conscious recollection of previously experienced events, whereas implicit memory is inferred from its effects on behaviour such as reaction time or performance accuracy, and subjects do not refer to the past in performing the test (Moscovitch, 1992). Moscovitch, Vrizen, and Gottstein (1993) demonstrated that implicit memory, which is assessed by performance on indirect memory tests such as reaction time or performance accuracy, is normal in amnesic patients who have severe impairments on direct memory tests such as recall and recognition.

There are a few ways to further fractionate explicit memory and implicit memory.

Explicit memory can be subdivided into episodic and semantic memory. Episodic memory refers to personal memories which include specific spatio-temporal information about the context in which an event occurred. For example, an answer to the question: *What were you doing when the World Trade Centre "911" tragedy took place?* requires episodic memory processes. On the other hand, semantic memory consists of fact-based general knowledge which is not associated with contextual information. For example, an answer to the question *Who was the first president of the US?* requires semantic memory processes (Tulving, 1984).

According to Moscovitch (1992), explicit tests can be classified as "associative/cue-dependent" and "strategic" tests. Associative tests are relatively automatic and mandatory and if the cue is appropriate, a memory can be brought to mind. For example, an answer to the question, "Have you ever been to Thailand?" is an example of an associative or cue-dependent test. On the other hand, an answer to the question, "What did you do yesterday?" initiates a memory search; the cue does not give rise to an associative response immediately. This is an example of strategic tests in which the questions often have a temporal component. Furthermore, Jacoby and Dallas (1981) proposed dual process theories which comprise familiarity and recollection. This will be described in details under the heading "Dual process theories of recognition memory".

Implicit memory can be subdivided further into "procedural" and "item-specific" implicit memory. Procedural implicit memory involves the acquisition and retention of general skills, procedures, rules, such as solving rule-based puzzles, learning motor tasks, reading novel scripts, whereas item-specific memory is associated with the acquisition and retention of particular information, such as words, faces and objects. On item-specific tests, the increased accuracy or speed due to repetition of previously seen items is known as "the repetition priming effect" (Moscovitch, 1992).

Studies of encoding

Studies have shown that deep encoding leads to better retrieval performance, when compared to shallow encoding (e.g. Craik, and Lockhart, 1972). In addition, research has shown that deep or semantic processing leads to a greater proportion of "remember" judgements (remember contexts and details), whereas shallow processing leads to a greater proportion of "know" judgements (a feeling of familiarity with the item)

(Tulving, 1985). Friedman and Johnson (2000) proposed that the different neural circuits recruited during retrieval should be formed during encoding.

Studies of retrieval

Retrieval of episodic memory is assessed with tests which make direct reference to a previous learning event; for example, recognition or recall. For recognition tests, participants are exposed to a series of items, and after some delay, they are tested with lists that comprise old items randomly intermixed with new items. The participant's task is to decide whether each item is old or new. Recall tests require participants to generate the old items with no cue, which is called "free recall", or from the fragment of the item, which is called "cued recall" (Friedman & Johnson, 2000).

Dual process model/ theories of recognition memory

Explicit memory can be further fractionated into familiarity and recollection (episodic retrieval) according to dual process theories (Jacoby & Dallas, 1981). These forms of explicit memory process reflect quality of the retrieval process. Recollection relates to "remembering", whereby the retrieved memory contains contextual information and phenomenal experience in which the studied item was encoded. It is a "contextual episodic component" process that retrieves detailed memory or specific information of studied items. Such information might include physical attributes, contextual or source information specific to the study episode (Curran & Dien, 2003; Friedman & Johnson, 2000). Familiarity, on the other hand, relates to a "Know" process, whereby the retrieved memory lacks both contextual information and phenomenal experience, but a feeling of familiarity is evoked. In other words, familiarity or "perceptual fluency" (Friedman & Johnson, 2000) is a subjective feeling thought to arise from an assessment of the global similarity between a test item and all studied list items (Raaijmakers & Shiffrin, 1992; Ratcliff & McKoon, 2000).

Face recognition illustrates the distinction between familiarity and recollection. We may experience a sense of familiarity when seeing a face; however, we cannot recollect details such as the person's name, or where (spatial) and when (temporal) he or she was seen last (Mandler, 1991). Furthermore, a few studies show that recollection fades more rapidly than familiarity (Gardiner & Java, 1991; Hockley & Consoli,1999).

Some researchers (Jacoby, 1991; Mandler, 1980) have associated familiarity with perceptual implicit memory and recollection with explicit memory. According to this view, the processes underlying familiarity on a word recognition test and word completion in an implicit memory test are the same. However, recent data from patients suggest that familiarity and implicit memory can be dissociated. Knowlton and Squire (1995) demonstrated that "Know" responses, which presumably are evidence of implicit or familiarity processes according to Jacoby (1991), also depend on the structures damaged in amnesia (i.e. Medial Temporal Lobe; MTL or diencephalic regions) which are the main regions associated with the explicit memory system (Squire, 1992; Friedman & Johnson, 2000). Stark and Squire (2000a) found that amnesics who showed normal implicit stem-completion priming were impaired on familiarity recognition tests. On the other hand, Wagner, Stebbins, Masciari, Fleischman, and Gabrieli (1998) found that a patient with right occipital cortex damage showed intact familiarity recognition, but impaired perceptual priming.

ERP studies of Memory: (i) Studies of encoding

Memory encoding refers to the processes which mediate between the experience of an event and memory formation of that experience (Rugg & Allan, 2000). Using ERPs to study memory encoding requires presentation of stimuli in a study task, while ERPs are recorded. Subsequently, memory for these stimuli is tested. ERPs are separated into two categories according to success and failure of memory retrieval: successful and unsuccessful. Subsequent memory effects presumably reflect variation in item encoding efficiency. Many studies have shown that haemodynamic and electrophysiological measures during the time of encoding can be predictive of later success and failure in retrieval memory performance (Sanquist, Rohrbaugh, Syndulko, & Lindsey ,1980; Okado & Stark, 2004). ERPs elicited by subsequently remembered items are more "positive-going" than those of forgotten items. This effect is sometimes called "Dm" which is short for "neural differences in subsequent memory performance" (Paller, Kutas, & Mayes, 1987).

Dm effects are mostly revealed when the ERPs for subsequently unrecognized or unrecalled items are subtracted from ERPs for subsequently recognized or recalled items. The magnitude of Dm seems to be related to the strength of the subsequent memory and the onset of Dm depends on the time which participants take to categorize a stimulus (Johnson, 1995). Dm effects appear over temporal and midline scalp around 250-800 ms after stimulus onset during the study phase. Paller (1990) found that Dm indexed memory encoding processes for explicit (i.e. cued recall, free recall) but not for implicit memory (i.e. stem completion).

Dm amplitude is quite small (1-3 uV); therefore, half of the studies have failed to find significantly different Dm effect (Johnson, 1995). This Dm effects may be equivalent to old/new effects in which more positive amplitudes are found for recognized or old items than unrecognized or new items, but Dm effects are elicited at encoding, whereas old/new effects are elicited at retrieval. Johnson (1995) hypothesized that Dm activity should be generated in the hippocampus which is an important part of the explicit memory system.

ERP studies of Memory: (ii) Studies of retrieval

ERPs and implicit memory

ERPs elicited by items that are repeated after a one minute or so interval in indirect memory tasks in which there is no requirement for intentional memory show a positive going shift relative to those elicited by first presentation. These ERP repetition effects which are elicited around 200 ms after stimulus onset respond to words, pronounceable non-words and pictures, but not unpronounceable non-words and meaningless pictures (Rugg, 1995). Tulving and Schacter (1990) proposed that this early ERP repetition effect reflects processes which underlie data-driven priming.

ERPs and explicit memory

ERPs and Recognition Memory: Dissociating Familiarity and Recollection.

A growing number of studies suggest that ERPs can be used to dissociate familiarity and recollection processes. ERPs are more positive when elicited by previously studied (old) than non-studied (new) stimuli starting around 300 ms after a recognition test item onset (Rugg, 1995). These “ERP old/new effects” or “ERP repetition effects” reflect the several cognitive events related to memory retrieval in both explicit and implicit memory tests (Paller, 2002). Friedman and Johnson (2000) prefer the term “episodic memory”: (EM) effect, which is equivalent to “ERP old/new effect”, because they consider it better describes the phenomenon.

Recent evidence has shown that an early ERP old/new effect (around 300-500 ms after recognition test items) may be related to familiarity whereas a later aspect (400-800 ms) may be related to recollection (Friedman & Johnson, 2000; Mecklinger, 2000). These ERP old/new effects co-occur with N400 and P300 components, respectively (Spencer, Vila Abad, & Donchin 2000). The 300-500 ms familiarity-related ERP effect has been called the frontal old/new effect. The 400-800 ms recollection-related ERP effect has been called the parietal old/new effect (Rugg et al., 1998; Wilding & Rugg, 1997a). These two effects will now be reviewed in greater detail.

<u>Familiarity assessment</u>: Frontal old/new effect

This frontal old/new effect appears around 400 ms post stimulus onset and is maximal over left prefrontal-central scalp (Friedman & Johnson, 2000). Smith (1993) found that its amplitude was the same whether the item was consciously recalled or evoked only feelings of familiarity. In addition, the frontal old/new effect responds similarly to studied items and lures (e.g. plurality reversed words, Curran, 2000; mirror-reversed pictures, Curran & Cleary, 2003; and semantically similar words, Nessler et al., 2001).

Curran (1999) called the familiarity-related effect the “FN400 old/new effect” because it is similar to the N400 related to semantic processing (Kutas & Petten, 1994). However, he found that the FN old/new effect is more frontally distributed than the centro-parietal N400 observed in language studies

Recollection: Parietal old/new effect

As characterized previously, old words elicit a more positive component than do new words. In recognition memory paradigms, processing new or unstudied words accesses semantic memory, whereas processing old or studied words accesses episodic memory (Friedman & Johnson, 2000). Wilding and Rugg (1996) suggested that the left parietal old/new effect reflects the successful retrieval of episodic information which is orchestrated by the medial temporal lobe memory system.

Initially, the episodic memory effect was thought to associate with familiarity processes (Rugg & Doyle, 1992). However, there is strong evidence for a relationship between the parietal old/new effect and recollection, and between its amplitude and retrieval success (Curran & Cleary, 2003). Firstly, the parietal old/new effect is associated with the recollection of specific information or source judgment such as study modality (Wilding & Rugg, 1997b), speaker's voice (Wilding & Rugg, 1996) and temporal source (Trott, Friedman, Ritter, & Fabiani, 1997). The parietal old/new effect is observed when such details are correctly recalled, but not when recognition occurs without such recollections. Secondly, the parietal old/new effect is sensitive to variables that affect recollection more than familiarity such as depth of processing (Paller & Kutas, 1992). Thirdly, larger parietal old/new effects are associated with items that were correctly recognized and given a "Remember" judgement when compared to that of a "Know" judgement (Smith, 1993).

Curran (2000) required participants to study lists of singular and plural words. Later on, participants were tested with studied words, similar lures, which were of opposite plurality to that of studied words, and new words. Participants were to make affirmative recognition judgments only for words tested in their original plurality and to reject any words that switched plurality (similar) or were totally new. It was found that the FN400 differentiated new from studied/similar words (new>similar/studied, ignore negative signs of polarity). This finding is consistent with the familiarity old/new effect by assuming that studied and similar items had comparable familiarity (Hintzman & Curran, 1994). In addition, correctly recognized studied words and falsely recognized similar lures can be differentiated by the parietal old/new effect (studied>similar=new). This again supports the association between the parietal old/new effect and recollection by assuming that recollection is more prevalent for hits than for false alarms (Yonelinas, 2001). In addition, amnesics with MTL damage show greater deficits in recollection than familiarity (Aggleton & Shaw, 1996; Yonelinas, Kroll, Dobbins, Lazzara, & Knight, 1998). Further research found that amnesic patients use a fluency heuristic as a default strategy, whereas control participants use this strategy when no information is available to support recollection (Verfaellie & Cermak, 1999).

Studies by Trott, Friedman, Ritter, Fabiani, and Snodgrass (1999) and by Wilding (1999) demonstrated that when participants correctly recognized an old item and also correctly identified its source, the left parietal old/new effect was larger than when the source was incorrectly identified, albeit each employed a different contextual feature to define source (Friedman & Johnson, 2000). Trott et al. (1999) used list membership (List1 and List 2), whereas Wilding (1999) employed gender of the voice in which the word was spoken for source detection.

However, the parietal old/new effect appears to be correlated with subjective experience of recollection (Smith, 1993). In addition, Curran and Dien (2003) found that old/new effects were not affected by study modality. Both visual and auditory modalities at study showed similar familiarity and parietal old/new effect in visual recognition tasks.

Source memory

Jacoby (1991) defined recollection as the ability to retrieve and make use of contextual or source information. “Source information or source memory” refers to memory for contextual attributes of a study episode such as when and where it occurred and the format or modality in which study items were presented (Rugg & Allan, 2000).

Rugg and Allan (2000) stated further that the accurate retrieval of information and context depends on recollection; however, retrieval of information without context depends on familiarity or weak recollection. Many researchers have arrived at a similar conclusion (Paller & Kutas, 1992; Smith, 1993).

Late right (pre)frontal old/new effect

This third type of old/new effect, which is not included in the dual process theories, is maximal over right frontal scalp around 500-590 ms post stimulus and may last until the end of the epoch (Friedman & Johnson, 2000). Friedman and Johnson (2000) argued that this long duration of the right frontal old/new effect may comprise multiple subcomponents, which make the interpretation of the results across studies difficult.

Wilding and Rugg (1996) were able to dissociate old/new effects on the basis of time course and scalp distribution, namely left parietal and right prefrontal old/new effects. They found that the right prefrontal old/new effect is largest for ERPs associated with correct source judgments. They linked the right prefrontal effect with post-retrieval evaluation which is engaged by tasks requiring contextual discrimination. The effect, which is prominent in source memory studies, fits well with evidence from lesion studies indicating that memory for source is impaired after damage to prefrontal cortex (Stuss, Eskes, & Foster, 1994). Allan, Wilding, and Rugg (1998) hypothesized that post-retrieval evaluation is engaged by prefrontal cortex to generate and maintain a representation of the study episode and to allow the information to be used in a goal-directed way. Some researchers have found that the greater the amount of information recalled, the larger is the magnitude of the right prefrontal old/new effect (e.g. Donaldson & Rugg, 1998). Curran, Schacter, Johnson, and Spinks (2001) also found that good performers, not poor performers, showed late right frontal ERP differences between new items and studied items or lures. This suggests that good performers, compared to poor performers, may have more efficient post-retrieval evaluation processes that are associated with late frontal ERP old/new effects.

However, the right prefrontal old/new effect is not simply correlated with successful episodic retrieval. Trott et al. (1999) found that the right prefrontal old/new effect was even larger when source retrieval was unsuccessful and was even elicited by new items that were falsely recognized as old (false alarms). Henson, Shallice, and Dolan (1999) found in their fMRI study that when participants were given either a “forget” or “remember” instruction, the right frontal effect was more activated for “forget” words than “remember” words. These findings are inconsistent with the notion that the right frontal effect reflects retrieval success. Henson, Rugg, Shallice, Joseph, and Dolan (1999) proposed that when information supporting a recognition judgement was relatively poor, such as in the absence of recollection, or when few retrieval products are available, monitoring operations or retrieval attempt would be engaged to a greater extent than when information was less ambiguous. Therefore, recognition judgements for words associated with a forget instruction require familiarity assessment followed by more extensive post retrieval evaluation. On the other hand, judgements for "remember" words require recollection and familiarity, and less post retrieval evaluation. In addition, Henson, Rugg, Shallice, and Dolan (2000) also found that recognition judgements (whether old or new) made with low confidence evoked greater right dorsolateral activity than those with high confidence. These findings suggest that this late prefrontal old/new effect reflects the engagement of monitoring and evaluation of the outcome of a retrieval attempt before selecting a response (Rugg, 2004) and successful recollections seem to be unnecessary for their elicitation (Mecklinger, 2000).

Mecklinger's (2000) Neurocognitive Model of Recognition Memory

The main features of Mecklinger's model are outlined in Table 1.

Table 1 A Neurocognitive Model of Recognition Memory (Mecklinger, 2000)

Processes	Familiarity assessment	Recollection	Post-retrieval evaluation
ERP-correlate	Frontal old/new effect	Parietal old/new effect	Late right frontal old/new effect
Timing	300-500 ms	400-700 ms	800 ms…
Some Experimental Manipulation	-Object recognition -TBR and TBF words -False and correct recognitions	-Spatial recognition -TBR words -Correct recognitions	-Object recognition -larger for TBF than for TBR words -False and correct recognitions
Brain Systems	MBTL Perirhinal cortex (?)	MBTL EHDC (?)	Right PFC

TBR=to-be-remembered; TBF=to-be-forgotten; MBTL=medial-basal temporal lobes; PFC=Prefrontal cortex; EHDC=extended hippocampal-diencephalic complex.

Mecklinger's (2000) model divided episodic retrieval of recognition memory into three components. First, familiarity assessment which is associated with a frontal old/new effect elicits between 300-500 ms post stimulus onset. He further stated that this frontal old/new effect overlaps with parietal old/new effects in some instances, but it is topographically different from a parietal old/new effect. This means that they reflect different memory processes. He proposed that this frontal old/new effect may "remind one of something" (Mecklinger, 2000, p. 578). Second, recollection which is associated with a parietal old/new effect elicited between 400-700 ms post stimulus onset. He stated that this parietal old/new effect may reflect modulations of the P300 component which is presumably associated with context updating processes. Third, post-retrieval evaluation which is associated with a late right prefrontal old/new effect begins around 800 ms post stimulus onset onwards and lasts until the end of epoch. He suggests that this late right frontal old/new effect reflects the engagement of cognitive operations that are set by the retrieval context. This late right frontal old/new effect reflects more global aspects of the context in which the retrieval takes place (Mecklinger, 2000).

Neuroanatomy of memory

The Medial Temporal Lobe and Memory

Scoville and Milner (1957) studied the patient H.M. and found that the medial aspect of the temporal lobe is crucial for memory function. Studies of amnesic patients have found that those with large medial temporal lobe lesions are much more severely amnesic than those who have lesions limited to the hippocampus or the hippocampus and entorhinal cortex (Corkin, Amaral, Gonzalez, Johnson, & Hyman, 1997; Rempel-Clower, Zola, Squire, & Amaral, 1996).

Further research with amnesic patients, monkeys and rodents has found that medial temporal lobe structures are essential for declarative memory. Nondeclarative memory appears to depend on other brain systems (Squire, 1992).

Findings from previous research have led to the conclusion that the major components of the medial temporal lobe system comprise the hippocampal formation (the CA fields of the hippocampus, the dentate gyrus, the subiculum, the entorhinal cortex) and the adjacent perirhinal and parahippocampal cortices (Squire & Zola-Morgan, 1991).

Recognition Memory and the hippocampus

Manns and Squire (1999) found that three patients with damage to the hippocampal region were impaired on both recall and recognition portions of the Door and People Test, a standardized test of memory. Functional imaging studies also show that the hippocampal region is activated during information retrieval in recognition memory tasks (Schacter & Wagner, 1999; Stark & Squire, 2000b).

Yonelinas, Hopfinger, Buonocore, Kroll, and Baynes (2001, cited in Yonelinas, 2002) found bilateral hippocampal and para hippocampal activation in their fMRI study in which participants were retrieving associative information accurately about study items of line drawings of objects (e.g. colour of items), but not item recognition for old and new items. They concluded that hippocampal and parahippocampal regions were involved in the associative test**,** which required recollection, not familiarity. Eldridge, Knowlton, Furmanski, Bookheimer, and Engel (2000) also found in their fMRI study that “correct remember” responses for words were associated with increases in hippocampal activation, whereas “know” responses were not. These studies indicate that the hippocampus is activated in recollection, but it is less activated in familiarity (Yonelinas, 2002).

The perirhinal cortex

Recent studies suggest that perirhinal cortex plays a crucial role in declarative memory, and the area TE plays a crucial role in visual information processing (Buffalo, Ramus, Squire, & Zola, 2000; Stark & Squire, 2000b). Therefore, patients with large temporal lobe lesions including perirhinal cortex, but not TE damage show memory impairment with spared performance of visual discriminations (Stark & Squire, 2000b).

The Mecklinger's (2000) model of recognition memory is applied partly as a conceptual framework for this thesis for frontal, parietal, and right prefrontal old/new effects. The intervals were adjusted to cover the FN400 for frontal old/new effects and P3 for parietal old/new effects that appeared in the present study. However, one should bear in mind that the paradigms and stimuli that were used in Mecklinger's framework and those of this thesis are different and different paradigms and stimuli could yield different topography and ERP old/new effects (Friedman & Johnson, 2000).

False recognition and ERPs

Nessler, Mecklinger and Penny (2001) found that ERPs for true (old/old) and false recognition (new/old) were more positive than for correct rejection (new/new) starting around 300 ms after test word presentation. These equal frontal old/new effects (300-500 ms) for true and false recognition reflect similar familiarity processes. However, smaller parietal old/new effects (500-700 ms) for false recognition reflect less active recollection, when compared to true recognition. Nessler and colleagues further showed that low false alarm participants were more careful when encoding item-specific features.

Buckner and Schacter (2004) also found that false recognition is increased in patients with frontal damage.

Schacter, Verfaellie, and Pradere (1996) found that amnesic patients with damage to either medial temporal lobe or diencephalic regions made fewer hits to studied items and more false alarms to unrelated lures. Interestingly, amnesic patients made significantly fewer false alarms to semantically related lure words. Amnesic patients also made fewer false alarms to perceptually related lure words (Schacter, Verfaellie, and Anes, 1997). These findings indicate that the medial temporal lobe and diencephalic regions, including frontal regions are involved in false recognition (Buckner and Schacter, 2004).

Buckner and Schachter (2004) have proposed that medial temporal lobe areas are engaged in the encoding and retrieval of semantic and perceptual gist or global similarity information that supports false recognition, and that amnesic patients reduce false recognition through an impairment of this mechanism (Buckner & Schacter, 2004). Therefore, when study list items were repeated, control participants can suppress false recognition and amnesic patients can have more false recognition rates (Schacter, Norman, and Koutstaal, 1998). Cabeza, Rao, Wagner, Mayer, and Schacter (2001) found that false recognition produced greater activation in right ventromedial prefrontal cortex than true recognition. They explained it as the engagement of monitoring processes that are demanded when participants attempt to judge “old or new” about lure items.

The evidence from the literature outlined above suggests that different ERP old/new effects reflect different memory processes, namely, familiarity, recollection and post-retrieval evaluation. This is proposed most explicitly in Mecklinger’s (2000) *model. On the hypothesis that individual differences in IS might reflect individual differences in memory, ERP old/new effects were used to examine the possibility that inter-individual variability in IS might be reflected in different patterns of ERP old/new effects. This in turn might shed light on the particular memory process or processes that are disturbed in suggestible individuals. It could not, however, be assumed that the spatio-temporal pattern of old/new effects as delineated in Mecklinger's model would emerge in the present study. This was because the experimental paradigm used in the present study did not fit the paradigm typically used in studies of recognition memory. The 3-stimulus oddball paradigm used here tested memory indirectly: although participants' judgement with regard to the pictures (relevant vs. irrelevant) depended on them recalling the content of the story, they were not explicitly asked to do so.*

An Overview of Attention

An overview of attention will first be given, followed by a review of studies that have looked at ERP correlates of attention. Since much recent research on ERPs and attention has focused on visuo-spatial attention, a brief review of findings in this area will be presented. The main focus of the review will be on studies using the visual modality (since the current study used visual stimuli), and on studies of attention that have used variants of an oddball task paradigm, where so-called targets, appearing against a background of frequent non-targets that require no response and can be ignored, have to be attended to and responded to.

James (1890) defines attention as "…the taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state… (pp. 403-404)".

Attention can be classified into active or voluntary attention and passive or reflexive attention. The voluntary attention in which we can choose the object of our attention requires effortful, top-down controlled process (Hopfinger, Luck, & Hillyard, 2004). However, some stimuli can distract our attention away from the task we are performing; for example, abrupt loud noise, infrequent events, our names being mentioned by chance. This switching of attention is passive attention (James, 1890) or reflexive attention (Hopfinger, Luck, & Hillyard, 2004). Passive attention is associated with elicitation of an "orienting reflex" or "orienting response" (Sokolov, 1963). This attention switch often affects patterns of overt and covert bodily changes. This passive attention phenomenon was first described by Pavlov (1927) and called by him the "what-is-it-reaction" or the "investigatory reaction". Reflexive attention requires a bottom-up process in which attention is captured by a stimulus in a rapid and involuntary way (Hopfinger, Luck, & Hillyard, 2004).

Naatanen (1992) specified that the passive attention or switching of attention is associated with distraction. We have to increase effort if we want to maintain our level of performance on the primary task (Kahneman, 1973). However, when we start to follow the distracting stimulus, it appears to capture our voluntary attention.

Divided attention occurs when participants are to monitor simultaneously two or several input sources; for example, listen to two stories concurrently, each story presented to one ear. Divided attention researchers are interested in how well people can perform two simultaneous tasks or how much performance decreases for the secondary task while performing the primary task (so called "divided attention" paradigm). Divided attention has been explained in terms of capacity limitation (Kahneman, 1973) or resource allocation (Naatanen, 1992).

ERPs and visuo-spatial attention

Researchers have found that stimuli falling within the spotlight of spatial attention elicit enhanced P1 (80-120 ms) and N1 (160-200 ms) components over posterior sites (Mangun & Hillyard, 1995). Mangun and Hillyard proposed that these enhanced components reflect changes in the excitability of the sensory neurons coding physical features of stimuli.

Mangun and Hillyard (1990) proposed that the P1 attention effect is caused by a modulation of sensory flow in the ventral prestriate visual projection stream to the temporal lobe that carries out functions of feature analysis and object recognition, whereas the N1 attention effect reflects attentional control over the dorsal projection to the parietal lobe (Harter & Aine, 1984).

Naatanen (1992) proposed that separate dorsal and ventral processing streams, originating in primary visual striate cortex, play different roles in visual perception (Desimone & Ungerleider, 1989). The dorsal stream which projects through the prestriate area V2 to the posterior parietal lobe seems to have a major role in encoding the spatial aspects of visual inputs and directing visuomotor performance. The ventral stream which projects through the prestriate areas V2, V3 and V4 seems to convey information about form, colour and pattern of stimuli to the inferior temporal lobe.

The evidence for attentional enhancement associated with the exogenous P1 and N1 in visual processing is very strong (Naatanen, 1992). In addition, some studies found a slow PN (processing negativity) deflection elicited by stimuli at the attended location. The PN deflection was prominent between 125 ms to 300 ms after stimulus onset and was greater over the occipital area contralateral to the attended visual field (Harter, Aine, Schroeder, 1982).

The N2 as well as the P3 seem to be elicited by any deviant stimulus in the attended channel. The N2 and P3 components have been shown to be decreased to stimuli at unattended spatial locations. The N2 is usually followed by the P3 and their association is very strong; therefore, the two have been referred to as the N2-P3a complex (Naatanen, 1992).

The N2 component in the visual modality has been considered to be an index of automatic, controlled stimulus evaluation and classification processes (Ritter, Simson, & Vaughan ,1983). When the separation between attended and unattended locations in the visual fields was very small, the N2 component was largest for attended-location targets, smaller for the target at unattended locations, and absent for unattended and irrelevant items (Wijers et al., 1987). However, Heinze, Luck, Mangun, and Hillyard (1990) found that the N2 component was absent in response to target stimuli at the unattended location.

Heinze, et al. (1994) found that both ERP and PET (Positron Emission Topography) studies showed that neural activity was selectively modulated in the extrastriate visual cortex contralateral to the attended hemifield.

ERPs and Attention in Oddball Tasks

The standard oddball task is one in which participants are required to detect rare task-relevant events (targets), embedded in frequent standard stimuli (non-targets). Whenever the rare task-relevant targets appear, participants are to make either an overt (motor) response or a covert response; for example, to mentally count the number of oddball exemplars. No response is required to frequent standard stimuli (Courchesne, Hillyard, & Galambos, 1975).

The oddball paradigm typically elicits a P300 response to target stimuli at posterior (particularly parietal) sites, referred to as the P3b component (Lindin, Zurron, & Diaz, 2004). Amplitude of this posterior P3 is maximal when participants are asked to respond to low-probability events and is thought to be sensitive to changes in the allocation of attentional resources and processes involved in contextual updating and decision making (Pritchard, 1981; Alexander et al., 1995; Donchin & Coles, 1998). *The oddball paradigm was used in the present study because the allocation of attentional resources was to be detected. The P3b, which appears to reflect the active allocation of attentional resources, was the focus in the present study's attempt to examine the attentional hypothesis of individual differences in IS.*

Attention, ERPs, and IS

Memory strength is directly related to how much attention people pay to an event (Gerrie et al., 2004) and Howard and Ng (2002) suggested that suggestible individuals may be characterized by a diffuse, unfocused attentional style, making them susceptible to distracting or task-irrelevant stimuli. Non-suggestible individuals, in contrast, would focus their attention more efficiently on task-relevant stimuli, disregarding the irrelevant distractors. Differences in IS might be related to individual differences in attention to task-relevant vis-à-vis task-irrelevant stimuli, and ERP measures sensitive to attention; namely, N1, P2, N2, and P3 were used to evaluate this hypothesis. It was predicted that if suggestible participants are inherently distractible, they would show relatively enhanced

ERP amplitudes to task-irrelevant distractors, and relatively smaller ERP amplitudes to potentially story-relevant targets.

An important *caveat* needs to be stated at this point. Attention and memory are complementary to one another, and interdependent. Explanations of IS in terms of attention and memory are by no means mutually exclusive. This point is brought home by results of a recent study by Curran (2004) which introduced an attention manipulation at the study phase of the verbal recognition paradigm. He reported that the parietal recollection old/new effect was sensitive to attention manipulation, while the frontal old/new effect was not sensitive to the manipulation. This result implies that to some extent recollection is the point at which memory and attention intersect and interact.

Research questions

Much research has been done on IS. These findings emphasize the importance of IS as a vulnerability factor for making false confessions. However, the underlying neurocognitive processes that cause individual differences in IS have never been studied. In other words, the question arises: What are the neurocognitive mechanisms that make some people more suggestible than others?

The present study aimed to examine the brain mechanisms that mediate individual differences in IS. The research questions posed in the present study were as follows:

1. What alternative criteria, other than GSS scales, may be used to distinguish low suggestible people from high suggestible people?

2. Can event-related brain potential (ERP) differences be demonstrated between high suggestible and low suggestible subjects?

3. What do the ERP differences between high and low suggestible subjects mean?

4. What are other psychological correlates of IS?

Examples of other possible correlates of IS include false alarm (FA) to lure and free recall of the Deese, Roediger-McDermott false memory paradigm (DRM paradigm, Deese, 1959; Roediger-McDermott, 1995), immediate and delayed recall of the GSS paradigm (Gudjonsson, 1997), reaction time, behavioural performance factors. As reviewed by Gudjonsson (2003), there is a relative dearth of studies that have examined personality correlates of IS.

5. What are the relationships of these psychological correlates of IS to ERPs?

6. What are the relationships between IS and personality?

A secondary aim of this thesis was to examine relationships between IS and personality variables, in particular compliance as measured by the GCS and the so-called the lexical view of Big 5 personality factors (Goldberg, 1990).

As reviewed above, a relationship between IS and (at least some) memory measures exists, but the type of memory problem experienced by suggestible individuals has so far not been explored. Moreover, most studies exploring the memory-IS relationship have relied on memory measures provided by the GSS scales that were also used to measure IS. Some studies did not find the correlations between suggestibility and memory, when other memory measures were used. Therefore, an alternative hypothesis might be that Interrogative Suggestibility is not related to memory, but to context-specific factors, as suggested by Bruck and Melnyk (2004). In the present study, the memory-IS relationship has been explored using GSS measures and other memory measures, including ERP measures. Apart from this, individual differences in attention play a prominent part in Loftus's theorizing (Gerrie et al., 2004). Howard and Ng (2002) have also postulated that individual differences in attentional style might underlie differences in IS.

In sum, the aims of the present study were twofold. First, to explore relationships between IS and memory performance, using a variety of memory measures and paradigms. Second, to explore ERP correlates of IS to distinguish two alternate hypotheses regarding the neurocognitive substrates of IS, one suggesting that differences in IS are attributable to individual differences in attention (Gerrie et al., 2004, Howard & Ng, 2002); the other suggesting that they are attributable to individual differences in memory (Gudjonsson, 2003). Of course, these hypotheses in terms of attention and memory are alternate but are not mutually exclusive – indeed, memory and attention are complementary processes. ERPs have been intensively studied over the past 20 years in relation to both memory and attention, and they offer a powerful tool for unraveling the parts played by memory and attention in IS.

Main Hypotheses

1. In terms of memory, based on reviews of the literature, most research suggests that recognition memory is related to interrogative suggestibility. Gudjonsson (2003) stated that suggestible individuals may suffer from the memory distrust syndrome. Therefore, suggestible individuals were predicted to show a lack of at least one of the ERP old/new effects which are components of memory (familiarity, recollection, and post retrieval evaluation), when compared to non-suggestible individuals. In addition,

poor performers (in free recall, oddball) were predicted to show lacks of the ERP old/new effects, when compared to good performers.

2. In terms of attention, suggestible individuals has more divided attention (Gerlie et al., 2004; Howard & Ng, 2002). It was predicted that if suggestible subjects are inherently more distractible, they would show relatively enhanced ERP amplitudes to task-irrelevant distractors, and relatively smaller ERP amplitudes to potentially story-relevant targets due to their diffused attention, whereas non-suggestible subjects would show relatively enhanced ERP amplitudes to task relevant targets due to their focused attention.

In the following chapter (Chapter 2), the methodology of the studies will be described, focusing on (i) cognitive/behavioural measures and (ii) ERP measures.

Chapter 2

Methods

As pointed out at the end of the previous chapter, the aims of the present studies were twofold. First, to explore relationships between IS and memory performance, using a variety of memory measures and paradigms. Second, to explore ERP correlates of IS to distinguish two alternate hypotheses regarding the neurocognitive substrates of IS. This chapter will outline the methodology used to achieve these aims, and will be structured accordingly. First, the overall design of the study will be described. Following this, the methods and measures used to measure IS, and its cognitive and behavioural correlates will be described. Then, the methodology of ERP recording and measurement will be described. Finally, the procedure and data analysis will be described in details. First of all, the glossary of memory and performance measures and their abbreviations that are used in the present study are shown in Table 2.

Table 2 Glossary of memory and performance measures and their abbreviations

TASK (abbreviation)	**DESCRIPTION**	**MEASURES (abbreviation)**	**DESCRIPTION**
DRM	**D**eese-**R**oediger-**M**cDermott false memory paradigm	DRM-FA	False alarms: critical lures falsely recognized as old. There are FA1 (first session) and FA2 (second session).
		Recall word (RW) DRM-free recall	Free recall: no. of words recalled out of max. 240.
		Old	Correct recognition: no. of words circled correctly “old” as “old” in the DRM questionnaire .
		Old2	Correct recognition: no. of words circled correctly “old” as “old” in another form of the DRM questionnaire (second session).
		New	Correct rejection: no. of words circled correctly “new” as “new” in the DRM questionnaire.
		New2	Correct rejection: no. of words circled correctly “new” as “new” in another form of the DRM questionnaire (second session).
ODDBALL	3-stimulus oddball task	Hit	Correct Recognition: story-relevant/old pictures correctly identified as such.
		CR	**C**orrect **R**ejection: story-irrelevant/new pictures correctly identified.
		Miss	Incorrect rejection: story-relevant/old pictures incorrectly identified as story-irrelevant/new.

Table 2 (continued)

TASK (abbreviation)	**DESCRIPTION**	**MEASURES (abbreviation)**	**DESCRIPTION**
ODDBALL		FA (oddball) FA-oddball	Oddball False Alarms: story-irrelevant/new pictures incorrectly identified as story relevant/old.
		C1	**C**ondition 1; geometric shape
		C2	**C**ondition 2, relevant-to-the-story/old pictures
		C3	**C**ondition 3, irrelevant-to-the-story/new pictures
		RT	Reaction Time (ms).
GSS	**G**udjonsson **S**uggestibility **S**cale paradigm	TS	**T**otal **S**uggestibility.
		Im-Re, Im-Recall	Immediate recall from the Gudjonsson Suggestibility Scale paradigm.
		De-Re, De-Recall	Delayed recall from the Gudjonsson Suggestibility Scale paradigm.
PEMQ	**P**ost –**E**vent **M**emory **Q**uestionnaire paradigm	Mislead, Misleading	Misleading questions in the Post-Event Memory Questionnaire paradigm.
		Repeat	Repeated questions in the PEMQ paradigm.
		Specific	Specific questions in the PEMQ paradigm.

Overall Study Design and Procedure

Participants were recruited in two waves (the reasons for conducting two waves as for theses development will be described in details later on), with the aim of recruiting individuals who would be more or less suggestible. In the first wave (referred to below as Study 1), 201 participants were recruited and were tested in 3 sessions.

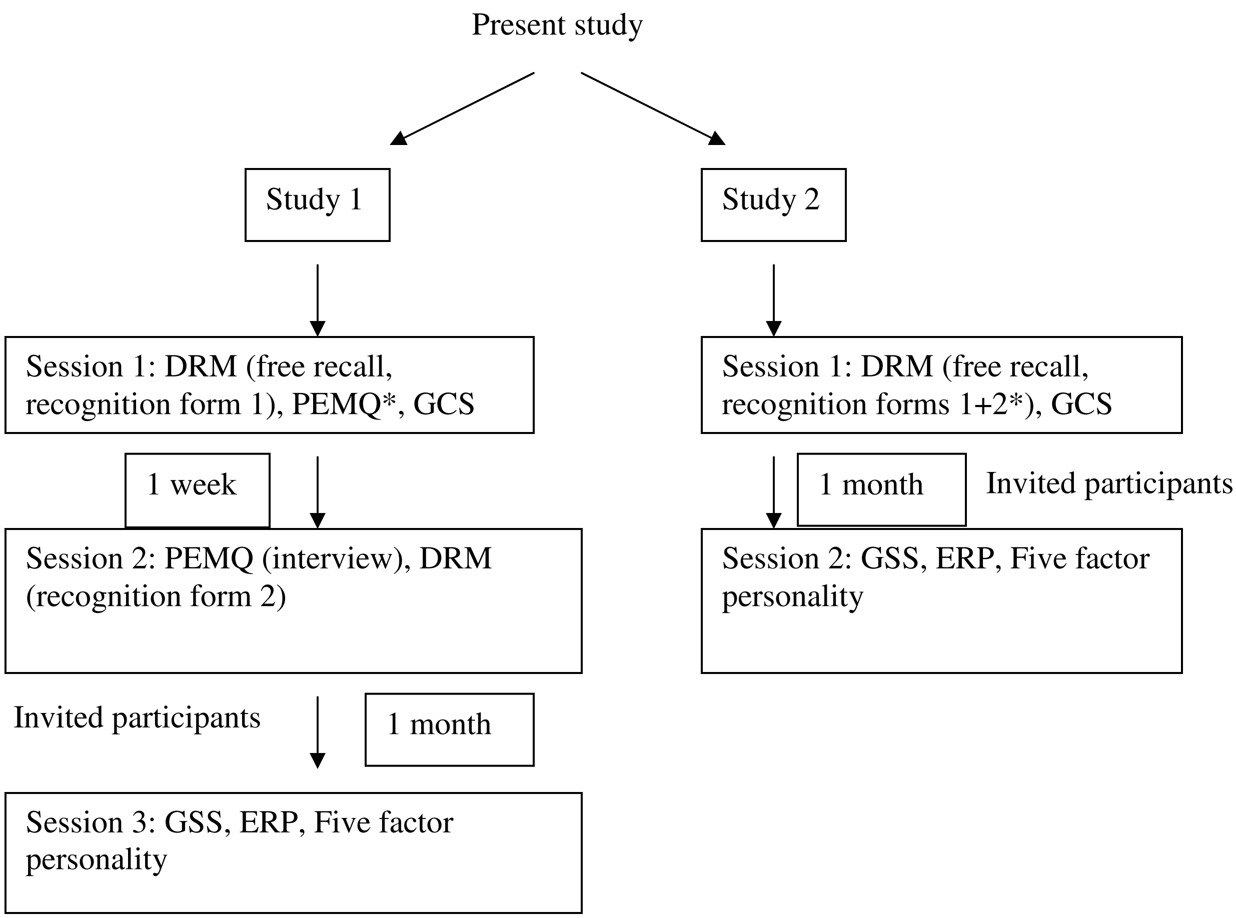
In the first session, participants underwent the PEMQ paradigm (Post-Event Memory Questionnaire; Eisen, Morgan, and Mickes, 2002) and the DRM paradigm (Deese-Roediger, McDermott list learning paradigm; Deese, 1959 and Roediger & McDermott, 1995) because both paradigms are supposed to produce the scores which are analogous to yield measures – misleading questions from the PEMQ and false alarms to lures from the DRM - that are related to suggestibility. In the second session, participants completed the second part of the PEMQ paradigm (interviewing) and the DRM questionnaire (the other form, either R1 or R2 counterbalanced). In the third session, selected participants underwent a GSS protocol and ERP measurement.

According to the results of the first session, the Yield or the Total Suggestibility scores of the GSS paradigm were correlated more to the false alarm to lure scores of the DRM paradigm than to the misleading scores of the PEMQ paradigm. Therefore, in the second wave, the DRM paradigm was used to preliminary screen participants for a GSS paradigm and ERP measurement. PEMQ paradigm was not used for Study 2.

In the second wave, referred to below as Study 2, 204 participants were recruited and were tested in 2 sessions. In the first session, participants underwent the DRM paradigm. In the second session, selected participants underwent a GSS protocol and ERP measurement. *The PEMQ paradigm was not administered in the second wave because results from the first wave indicated that PEMQ measures did not correlate reliably with GSS Interrogative Suggestibility.*

The overall procedure was summarized in Figure 3.

Figure 3 Procedure of the present study (* The criteria to invite participants to ERP and GSS measurement was the misleading question of the PEMQ for Study 1, and the false alarm to lure of the DRM recognition questionnaire for Study 2)



<u>Variables for ERP analyses</u>

1. <u>Independent variables</u> are as follows.

1.1 <u>Between subjects variables:</u>

1.1.1. Sex (male, female)

1.1.2. GSS (GSS1, GSS2)

1.1.3 Low and high groups of IS and memory variables such as TS, yield, shift, free recall from GSS and DRM paradigm.

1.2 Within subjects variables:

1.2.1 Electrode sites (Channels; e.g. pFz, Fz, etc.) and Intervals of ERPs (e.g. 250-350 ms, etc. after stimulus onset)

1.2.2 Conditions (C); C1, C2, C3

1.2.3 Regions (e.g. LPF, FC, RPF, etc.)

2. Dependent variables are as follows.

2.1 Average & peak amplitudes (uV) for memory & attention effects, respectively and latencies (ms) of ERPs

Methods and measures

1. Interrogative Suggestibility measures

Gudjonsson Suggestibilty Scale Paradigm

The procedure used for administering the GSS was as prescribed in the manual (Gudjonsson, 1997). Either GSS1 or GSS2, counterbalanced across participants, was presented to participants as a memory test. In this thesis, each participant listened to the story from the audio tape player recorded with a female voice. After listening to the story, participants were asked to recall everything that they could remember about the story (immediate recall). After 50 minutes had elapsed since listening to the GSS story, participants again were asked to recall everything that they could remember about the story (delayed recall). Then, participants were asked a series of questions regarding the story. There were 20 questions which comprised 15 leading questions and 5 factual questions (see Appendix A). The 15 questions gave the Yield1 score which was the responses in the affirmative to leading questions. After questioning and answering, negative feedback was given, as follows: *You have made a number of errors. It is therefore necessary to go through the questions one more time and this time try to be* *more accurate*. Then, participants answered the series of questions again. This second questioning gave the Yield2 score which was derived from the affirmative responses to 15 leading questions, the Shift score which was the number of times the participant changed his/her answer in response to a question, out of a total of the 20 questions and Total Suggestibility scores (TS, Yield1 plus Shift). After the experiment was finished, participants were debriefed and were assured that they did not have anything wrong regarding their memory.

In sum, the GSS paradigm is conducted in steps as follows.

1. Listening to a GSS story, either GSS1 or GSS2, from a tape player.
2. Immediate free recall
3. Delayed recall (50 minutes after listening to the GSS story).
4. First interrogation administered: “Yield1” obtained.
5. Negative feedback provided.
6. Second interrogation administered: “Yield2” and “Shift” obtained.

The Gudjonsson Suggestibility Scales (GSS) offer unique advantages in examining hypotheses regarding the neural mechanisms underlying individual differences in IS and memory. First, they afford measures not only of IS (Yield and Shift), but also of verbal memory recall (both immediate and delayed). Second, the GSS protocol offers a convenient time window, the 50-minute delay period between immediate and delayed recall, during which ERP recordings can take place. Third, advantage can be taken of the fact that the stories used in GSS1 and GSS2 lend themselves to graphic representation of scenes from the narratives, which can be used to elicit ERPs. Moreover, the stimulus set that serves as story-relevant pictures for participants undergoing GSS1 can serve as story-irrelevant pictures for participants undergoing GSS2; conversely, pictures relevant to GSS2 can serve as story-irrelevant pictures for participants undergoing GSS1. Fourth, participants can be grouped on the basis of their scores on the Yield and Shift measures of IS as “high suggestible” and “low suggestible” and compared in terms of ERP old/new effects. Since the story-relevant pictures depicted scenes from the previously heard GSS narrative, they can also be considered “old” in the context of ERP old/new effects. Conversely, the story-irrelevant pictures can be considered as “new”.

In sum, the variables of IS that derived from GSS scales and were used in this thesis are as follows:

1. Yield1 refers to the number of leading questions that a participant yields to prior to negative feedback. The maximum score is 15.

2. Shift refers to the number of times that a participant has a distinct change in his or her answers following the negative feedback. The maximum score is 20.

3. Yield2 refers to the number of leading questions that a participant yields to after the negative feedback. It provides additional information regarding the subsequent susceptibility of a participant to leading questions after negative feedback. The maximum score is 15.

4. Total Suggestibility (TS) represents the sum of Yield1 and Shift and gives a participant’s overall total suggestibility. The maximum score is 35.

In addition to the suggestibility measures, GSS gives measures of immediate and delayed recall, and a confabulation measure (not used in this thesis).

<u>GSS free recall</u>

1. Immediate recall provides a measure of immediate verbal recall on the GSS story. According to Gudjonsson (1997), it gives an indication of a participant's attention, concentration, and memory capacity. The maximum number of ideas that a participant can recall is 40.

2. Delayed recall obtained 50 minutes after listening to the story. The maximum score is 40, as with immediate recall.

2. Non-GSS Memory Measures

<u>The Post-Event Memory Questionnaire</u> (PEMQ)

This questionnaire was developed by Eisen, Morgan, and Mickes (2002). Participants underwent two sessions. In the first session, participants entered the room which was decorated according to the questions being asked in the PEMQ paradigm of session 2. Participants were asked to undergo the DRM paradigm (e.g. listening to 16 wordlists and making free recalls) and complete the GCS scale. In session 2, one week later, participants were administered an unexpected measure of event memory related to the details of their experiences in the previous session (session 1). The PEMQ was administered by a different experimenter and in a different room from which participants had visited in the previous session. The PEMQ consisted of 57 items (see Appendix C).

The PEMQ has five categories of questions; namely, 11 open question, 20 specific questions, 4 repeated (specific) questions, 22 misleading questions which comprise 20 misleading questions and 2 repeated misleading questions. However, the scores of open questions were not used in this thesis.

Specific questions according to Eisen et al. (2002) were designed to be clear, direct, and non-suggestive. Misleading questions all stated facts contrary to the actual experience of the participants and were analogous to leading questions that generate the Yield score in GSS scales. Repeated questions within the interview instills uncertainty that provides an analogue to the Shift score on GSS scales. However, for the PEMQ, negative feedback is not explicitly provided to participants, unlike GSS scales in which negative feedback is explicitly given.

False recognition

False recognition refers to the tendency of participants in recognition tests to classify new or unstudied items as old or studied items, also called “false alarms” to new items (Rugg & Allan, 2000). Sometimes new words used in false recognition tests are words that are associated in meaning to studied word lists. Misclassification of these new words that are semantically related to old words can be referred to as “false alarms to critical lures”. Schacter, Verfaellie, and Koutstaal (2002) suggested that gist information, or overreliance on shared semantic or perceptual features, is basically responsible for false recognition in the DRM (Deese, McDermott list learning paradigm, Deese, 1959; McDermott & Roediger, 1995) and related paradigms. They also suggested another possible explanation for false recognition in the DRM paradigm in that it may be a consequence of “implicit associative responses” that occur when participants are exposed to semantic associate lists during the study phase of the experiment. They further explained that participants may activate or unconsciously generate the non-presented lure words. Therefore, participants may experience source confusion and misunderstand that they heard or saw the theme word they themselves have generated.

Gonsalves and Paller (2000) instructed participants to generate a visual image of objects when the corresponding words were shown . For half of the words, the picture of that object was never presented; for the other half of the words, the picture was presented after the word. They found that participants claimed to remember some of the-non presented pictures which can be considered as a type of “false memory” or “source-monitoring errors” (Johnson, Hashtroudi, & Lindsay, 1993).

The Deese-Roediger McDermott list learning paradigm (DRM paradigm)

The DRM paradigm was first developed by Deese (1959) and then Roediger and McDermott (1995). Participants listen to 16 lists of 15 words each from the audio tape player recorded with a male voice. After each list, participants were asked to write down the words that they could recall on a piece of paper, regardless of word order (DRM free recall). A separate piece of paper was provided for each list and participants turned over the paper after they had finished writing down each list. They were given a maximum of two minutes to write the words from each list. Participants’ performance was scored by the number of words that they could recall correctly (DRM free recall).

After finishing all of the lists, participants performed the recognition test, administered via a questionnaire. There were two forms of the questionnaire (R1 and R2). For Study 1, two forms (R1 and R2) were used in separate sessions, but for Study 2, two forms were collapsed as one form and used in the first session (see the reason for doing this in the procedure later on). Each form comprised old and new words, as well as critical lures. Participants had to decide whether the words were “old” (previously presented) or “new” (not previously presented). Critical lures were words that had not previously been presented (they were new), but because they were semantically related to the words in the lists, they tended to evoke false alarms (false recognitions). For example, in the word list comprising *boy, dolls, female, young, dress, pretty, hair, niece, dance, beautiful, cute, date, aunt, daughter and sister,* the critical lure was *GIRL*.

The words in the ranks of 1, 8 and 10 of each list (see Appendix D) were used as the old words in the questionnaire. The words from the remaining lists that did not appear in the 16 presented word lists of the same ranks (1, 8 and 10) including critical lures of these lists were used as the new words (only the first 16 lists appeared in the audio tape player). Words were randomly selected to appear in the questionnaire. In total, there were 48 old words, 32 new words and 16 critical lure words (see Appendix D for the lists and the questionnaires, R1 and R2).

For the questionnaire, there were three scores that derived from the questionnaire; namely, the "old" score in which participants correctly circled "old" as "old" words, the "new" score" in which participants correctly circled "new" as "new" words, and the "false alarm" scores in which participants incorrectly circled "old" which were actually "new" words.

3. Performance Measures

<u>Oddball task: its reaction time and accuracy</u>

The standard so-called oddball paradigm is a task comprising 2 categories of stimuli, targets and non-targets, where the targets occur infrequently and require some sort of overt or covert response from the subject. The non-targets can be ignored. The oddball paradigm is frequently used in studying attention in which participants always pay attention to infrequent target stimuli. This is the reason for using oddball paradigms in ERP studies of attention.

This study used a variant of the oddball paradigm, a so-called 3-stimulus oddball paradigm, comprising 3 categories (conditions) of stimuli. Category 1 comprised frequent non-targets (geometric shapes) that occurred frequently (80% of trials). Categories 2 and 3 were rare (10% of trials each) targets that required the participant to discriminate between story-relevant (Category 2) and story-irrelevant (Category 3) pictures. The oddball task required participants to press the buttons to rare target stimuli in which the reaction time and accuracy (hit and correct rejection) of these types of stimuli, including the errors (miss and false alarm) could be compared between low and high groups of variables of interest. A "hit" refers to participants' correct identification of a story-relevant picture by pressing the appropriate response button. A "correct rejection" refers to participants' correct identification of a story-irrelevant picture by pressing the appropriate button. A "miss" refers to participants' incorrect identification of a story-relevant picture as irrelevant, by pressing the wrong button. A "false alarm" refers to participants' incorrect identification of an irrelevant picture as relevant, as indicated by pressing the wrong button.

4. Personality Measures

The Gudjonsson Compliance Scale (GCS)

The GCS comprises 20 items. Gudjonsson (1989) rotated the scale using the Varimax procedure and he found that three factors had an eigenvalue greater than one. Factor 1 on which ten items loaded, comprised items that related to the avoidance of conflict and confrontation when in the company of other people. Factor 2 comprised five items and reflected eagerness to please. Factor 3 comprised five items which reflected a mixture of compliant behaviours.

Gudjonsson (1997) stated that the GCS tends to be more stable over time than the GSS scores because it is based on a self-report rather than a behavioural measure of a simulated interrogative situation. The GCS (Form D) was used in this thesis and is a self-report questionnaire with the answer "true or false" (e.g. I give in easily when I am pressured, see Appendix B). Gudjonsson (1997) stated that there is a certain conceptual overlap between compliance measured from the GCS and IS measured from the GSS because he found that there was a significant correlation (albeit a poor correlation) between GCS scores and GSS scores; however, Smith and Gudjonsson (1995) failed to find the correlation between TS scores from GSS scales and GCS scores.

In the present study, the reliability (Cronbach's alpha) of the GCS = .85.

Five Factor Model of Personality

The personality questionnaire used in this study was the five factor personality (the "Big Five"). This questionnaire was originally developed by means of a lexical and statistical approach. Allport and Odbert (1936, cited in Larsen and Buss, 2002) went through the dictionary and identified some 17,953 trait words from the English language. Cattell (1943) grouped these trait words into a smaller set of 35 clusters of personality traits. Fiske (1949) took a subset of 22 clusters of Cattell's 35 clusters and discovered five factors by factor analysis. Fiske then is noted as the first person to discover the five factor model; however, he is not credited for having identified its precise structure because his sample size was small (Larsen & Buss, 2002).

Tupes and Christal (1961, cited in Larsen and Buss, 2002) made further contribution to the five-factor taxonomy by examining the factor structure of the 22 simplified descriptions in 8 samples. They found the five factor model which comprised surgency, agreeableness, conscientiousness, emotional stability and culture. This factor structure was replicated by Norman (1963) and other researchers using different samples. Goldberg (1990) has done the most systematic research on the Big Five using single word trait adjectives. The factors and key adjective markers that Goldberg confirmed are similar to Norman's, namely:

1. Surgency or extraversion (talkative, extraverted, assertive, forward, outspoken versus shy, quiet, introverted, bashful, inhibited);

2. Agreeableness (sympathetic, kind, warm, understanding, sincere versus unsympathetic, unkind, harsh, cruel);

3. Conscientiousness (organized, neat, orderly, practical, prompt, meticulous versus disorganized, disorderly, careless, sloppy, impractical);

4. Emotional stability (calm, relaxed, stable, versus moody, anxious, insecure);

5. Intellect or imagination (creative, imaginative, intellectual versus uncreative, unimaginative, unintellectual).

Another form of Big Five using sentence items was developed by Costa and McCrae (1992) which is called Revised NEO Personality Inventory (NEO-PI-R). This NEO-PI-R consists of 240 statements to which the person indicates an extent of agreement on a 5-point scale (e.g. I have frequent mood swings). This scale further differentiates each factor into six underlying subcomponents. Each of the subcomponents is assessed by eight items. They reported consistent convergent and discriminant validity with respect to adjective checklist measures of Goldberg (1990, 1992).

The five factor model has been replicated widely and shows the same factor structure in males and females.

In this thesis, Goldberg (1990)'s five factor model was used. The adjectives were randomly placed in 42 items of the questionnaire and participants rated them using a 7-point Likert scale from "doesn't apply to you at all (1)" to "applies completely (7)" (see Appendix E). The scores for negative adjectives were reversed before summing up to the total scores for each factor. The Cronbach's alpha for the extraverion subscale=.88, the agreeableness subscale=.79, the conscientiousness subscale=.88, the emotional stability subscale=.65, and the intellect subscale=.77.

5. ERPs and their measurement

In this section the focus will be on methodological aspects of ERP recording and analysis.

<u>Purpose of the ERP study</u>

As stated in Chapter 1, the main purposes are to see the difference between low and high groups of IS and variables of interest in overall ERP perspective and in terms of memory and attention effects on ERPs and their oddball performance. The oddball paradigms are always used in the study of allocation of attention. The 3-stimulus oddball paradigm employed here to detect differences of low and high suggestible individuals in the allocation of attention for potentially task-relevant stimuli (Condition 2 & 3) and task-irrelevant stimuli (Condition 1). The P3b components of ERPs are always elicited when low frequency stimuli are targeted. In addition, this oddball paradigm can be used to study recognition old/new effects. Pictures that related to the GSS story can be considered as "Old" effects, and pictures that unrelated to the GSS story can be considered ad "New" effects.

The paradigm used here was cross-modal (auditory at study, visual at test), but cross-modal ERP old/new effects have previously been described using more traditional verbal memory paradigms (e.g. Curran and Dien, 2003; Nessler, Mecklinger and Penney, 2001). Although ERP old/new effects have overwhelmingly been studied in standard verbal recognition memory paradigms, ERP old/new effects are not restricted to recognition of old vs. new words. They have also been reported for a paradigm using recognition of pictures (e.g. Curran and Cleary, 2003).

Procedure

Two related studies were conducted consecutively using different samples (see also Figure 3, p. 61 for the procedure diagram). Two studies were conducted separately due to the thesis development.

Study 1

Participants

204 undergraduate students (45 males, 159 females) from the National University of Singapore participated in this study as a part of their course credit requirement.

Memory measurement

There were three sessions. Participants were tested singly in all of the sessions. In the first session, participants came to the room which was decorated in accordance with the PEMQ administration; for example, it had a vase of flowers, a mirror on the table and so on. The experimenter also behaved according to the PEMQ paradigm; for example, shook participants' hand, went out from the room some time during the experiment, and so on.

Then, participants went through the DRM paradigm (Roediger & McDermott, 1995, see Appendix G for the DRM instruction). At the conclusion of the DRM free recall, participants filled out the recognition questionnaire by circling “old” for words that they thought they had heard in the lists and “new” for words that had not appeared in the lists.

For Study 1, this recognition questionnaire split into two forms, R1 and R2 (see Appendix D), counterbalanced for order across participants. For Study 2, the two forms were collapsed into one questionnaire the reasons for which will be discussed later on. Finally, participants completed the GCS questionnaire form D (Gudjonsson Compliance Scale; Gudjonsson, 1997). Then, the participants were reminded to come again one week later for Session 2 which took place in a different room. The first session took approximately 50 minutes.

The second session was conducted by another experimenter. Participants completed the alternate form of the DRM questionnaire (R1 or R2 form, counterbalanced across participants). Then, participants were interviewed individually using the PEMQ paradigm (Post-Event Memory Questionnaire; Eisen, et al., 2002, see Appendix C). The PEMQ comprises 57 questions. All interviews were audio recorded for future reference. Finally, participants were told not to tell the details of the experiment to other participants and the debriefing will be sent by email once the overall experiment was completed. This second session took around 20 minutes.

The misleading question scores of the PEMQ was used as the criterion for inviting participants to come to participate in the GSS paradigm and the ERP assessment of high and low IS individuals. Eisen et al. (2002) stated that “the immediate acceptance of misinformation as assessed by errors on misleading questions is very close to IS as assessed by the GSS (pp. 565)". They further stated that yielding to misleading questions on the PEMQ is roughly analogous to Yield1 scores of the GSS.

For the third session, participants who had extremely low and high misleading question scores of the PEMQ were contacted around 1 month after session 2 to come to participate in the ERP measurement session.

The maximum possible score of the PEMQ misleading questions is 22. For 204 participants, the score range was 2-14 ($\underline{M}$ = 7.88, $\underline{SD}$ = 2.33). Based on the misleading question curve, participants who had the misleading question scores of the PEMQ 2-6 (extremely low) and 10-14 (extremely high) were contacted to come for the ERP measurement for 2 hours with 14 S$ remuneration.

<u>ERP and GSS measurement</u>

As described in Chapter 1, ERP measurement was used in this thesis in order to find differences of memory and attention of low and high suggestible individuals. Moreover, ERPs could yield the differences of memory in terms of memory components. The oddball task paradigm of the ERP measurement is always used in the study of attention. In the oddball task, there are categories of stimuli which have low and high frequencies (as described in details in Chapter 1). The categories of low frequency (oddball) target stimuli could draw more attention from participants and therefore could produce P3 (or P3b) components which are related to attention.

When participants came to the laboratory room, they were given an outline of the experiment as a memory experiment without mentioning about IS. Participants then signed the informed consent form. The 32 electrode headcap (Electro-Cap International. Inc.) was then applied to the scalp of the participant. The placement of the electrodes followed the 10-20 international system. After the electrodes were applied, the partcipant proceeded to the subject cubicle room.

At this time, the participant was encouraged to relax. Electrode cables were plugged into the BIOSEMI data acquisition equipment which was connected to the computer in the control room to check for EEG signals. Then, during the interval between immediate and delayed recall, the GSS paradigm was conducted, following the GSS manual (Gudjonsson, 1997).

Participants listened to either GSS1 or GSS2 story counterbalanced across participants. Participants were told to remember the details of the story as they would be asked to tell everything that they could remember about the story later on. Then participants did the immediate verbal recall which was recorded in the tape recorder for future reference, at the same time it was scored on the GSS sheet (see Appendix G for the instructions).

After that, participants underwent the ERP recording, with a three stimulus oddball paradigm, by using BIOSEMI acquisition program (version 3.38) with sampling rate 2048 Hz and bandwidth (3dB) is DC to 417 Hz. After finishing ERP recording, participants proceeded to the preparation room. The cap of electrodes was removed and their heads were cleaned. Participants were told to relax and fill in the questionnaire pertaining to five factor personality for about 15-20 minutes (see Appendix E).

When they had completed the questionnaire, they were told to wait until 50 minutes had elapsed since they started listening to the GSS story. They were asked again to recall the contents of the story (delayed recall) which was scored and recorded. Shortly after this, they were asked the 20 questions to obtain Yield1 scores. They were next given the negative feedback (produced Shift scores in case they changed their answers) and then asked the same questions again to obtain Yield2 scores. Their answers were recorded in the tape recorder for future reference. Total Suggestibility (TS) was calculated as the sum of Yield1 and Shift scores. Finally, participants were shown their EEG signals and responses and participants were told that the full debrief would be sent by email after all the experiments were completed.

For the ERP session of Study 1, there were 50 participants participating with the remuneration of S$14 per 2 hour session. 25 participants were in GSS1 and the other 25 participants were in GSS2. However, one participant of GSS1 was dropped from the analyses (both behavioural and ERPs analyses) at the very beginning due to the noisy brain waves.

Stimulus materials and presentation

The distance between the participant's nasion and the centre of the monitor was kept constant at 80 centimetres. A three-stimulus oddball paradigm was used for the recognition test. All of the stimuli were black line drawings (10cm x 10cm) against a white background when presented on the monitor. Each of the stimuli was subtended an horizontal angle of 20 degrees.

The stimuli comprised 3 conditions (C) of pictures with a total of 220 trials. Condition1 (C1; geometric shape) was 80% (176 trials). Condition2 (C2; pictures relevant to the story, old pictures) was 10% (22 trials). Condition3 (C3; pictures irrelevant to the story, new pictures) was 10% (22 trials). C2 and C3 pictures were randomly presented among the geometric shape pictures.

If the participant listened to the GSS1 story, the irrelevant or new pictures were the pictures from GSS2, or vice versa. The pictures were obtained from an artist's impression upon reading the stories (for all of the pictures used, see Appendix F). Inter-rater agreement for the categorization of each picture into GSS1 and GSS2 was .98 (Howard & Goh, 2002).

WESP (Wesp Experimentation Stimulus Program by Molenkamp, 2002) was used for the stimulus presentation program and behavioural recording (reaction time, and response accuracy). The duration of each picture presentation on the screen was 2 seconds with a pseudo-random inter-stimulus interval varying from 3.5 to 4.5 seconds.

Task paradigm

Participants' task was to observe the pictures and to discriminate behaviourally between those that were related to the story (story-relevant pictures) and those that were not related to the story (story-irrelevant pictures) by pressing the left or right button, using the index and middle fingers respectively, of their right hand. The association between response (left and right button press) and story relevance was counterbalanced across participants. They were not to press any buttons when they saw the geometric shape pictures, just only see and let them pass (see Appendix G for the oddball task instruction). In order to make sure that they understood the task instruction, participants were given a practice session comprising about 10 trials using a separate set of stimuli.

EEG recording

EEG was recorded using the EEG cap with 32 + 2 ground electrodes and the two vertical and two horizontal eye movement electrodes with the electrode gel for conductivity. The vertical and horizontal electro-oculograms (EOGs) were recorded from electrodes placed above and below the outer orbits of the right eye, and from left and right outer canthi respectively. The two electrodes at the mastoid bones behind the ears served as reference electrodes. The electrode locations can be seen in Figure 4. The EEG signals were acquired using the Biosemi Active Two measurement system with active electrodes and data acquisition software version 3.38 (see http://www.biosemi.com). Raw data were saved in bdf file format as default.

Behavioural recording

Reaction time and response accuracy were recorded on-line by the WESP program during ERP recording.

The reason for conducting Study 2

The reason that Study 2 had to be conducted was that there were a small number of subjects to be analyzed for acceptable statistical power. Study 2 was conducted almost immediately after Study 1 had been finished.

The result from Study 1 found that the correlation between the Yield1 score and the false alarm to lure score of the DRM (circle old which is actually new), $r=.37$, $p<.05$, $N=50$, collapsing between GSS1 and GSS2, males and females, was more than the correlation of the Yield1 score and the misleading question score of the PEMQ ($r=.24$, $p<.09$, $N=50$). In addition, the correlation of the TS score and the false alarm to lure score, $r=.41$, $p<.01$, $N=50$, was more than the correlation of the TS score and the misleading question score of the PEMQ, $r=.29$, $p<.05$, $N=50$. These mean that the false alarm to lure score will be a better screener for interrogative suggestibility than the misleading question score of the PEMQ. Therefore, Study 2 was conducted by using the *false alarm to lure score (DRM-FA) as the preliminary screening criterion of suggestibility for selecting participants to attend Study 2.*

Study 2

Participants

201 undergraduate students (158 females and 43 males) from the National University of Singapore who had not participated in Study 1 participated in this study as a part of their course credit requirement. Study 2 was identical to Study 1 except that (a) there was only one session before the ERP assessment because the PEMQ paradigm was not used in Study 2; (b) therefore, there was only one version of the DRM questionnaire; version 1 and 2 were collapsed; (c) DRM data was acquired from groups of 10-20 persons to save time. All of the participants were told that they might be contacted to come for another experimental session with some remuneration.

The maximum possible score of the false alarm to lure score was 16. For 201 subjects, the score range is 2-16 (M=10.53, SD=3.28). Participants who obtained a false alarm score of less than 7 or more than 13 (extremely low and high scores based on the curve) were contacted after session 1 to come to the ERP measurement for 2 hours with either 10 S$ remuneration or course credits. The ERP measurement was conducted around 1 month after the DRM session.

For the ERP session, there were 47 participants participating with the remuneration of S$10 per 2 hour session. 21 participants were in GSS1 and the other 26 participants were in GSS2. However, two participants of GSS1 was dropped from the analyses (both behavioural and ERPs analyses) at the very beginning due to the noisy brain waves.

ERP measurement and procedure

ERP measurement and procedure were the same as Study 1.

Data analyses of memory, suggestibility, oddball performance measure and five factor personality for Study 1 and Study 2

Since participants from Study 1 and Study 2 went through the same processes of the GSS paradigm and the ERP data collection except the screening procedures at the very beginning for inviting participants to the GSS paradigm and the ERP data collection, it is legitimate to collapse across Study 1 and Study 2 as one study (88 males, 317 females). False Alarm (FA), New and Old scores of the first session of Study 1 were doubled to make it comparable to these scores of Study 2. In addition, for correlation analyses, data are collapsed across males and females. This is because the correlations when males were excluded or included showed the similar results and it is difficult to recruit male participants to meet statistical power. Bruck and Melnyk (2004) also suggest that “it is recommended that gender be included as a factor in the analysis of suggestibility studies only if there is a primary theoretical motivation for its inclusion (p.986)” because they found the inconsistent gender differences in their literature reviews.

As for independent t-test analyses compared between GSS1 and GSS2, males and females were also compared and shown because there were a few differences between males and females. GSS1 and GSS2 were analyzed both separately and as a whole to compare the results, and to see the overall picture.

The skewness for all variables was explored. Only the repeated question of the PEMQ had moderately positive skewness; therefore, square root transformation was applied to the original data of this variable; however, the correlations of the original data and the transformed data with other variables yielded very similar results. Thus, the original data of this variable was used for analysis.

To screen for outliers, participants whose scores were beyond z-score = 3.3 and less than z-score = -3.3 in case of N>/=100, and z-score= +/-2.58 in case of N<100 were dropped from the analysis (Tabachnick & Fidell, 2001). The number of the participants for each variable was not equal due to missing data of incomplete questionnaires or dropped outliers.

Factor analyses and Pearson correlations *(two-tailed)* were performed for the variables of interest. In addition, ANOVAs and independent t-tests were used to compare oddball performance (reaction time and accuracy) between low and high groups of individuals.

The criteria of low and high groups of IS and memory performance (by means of extremity in frequency curves) were set separately for Experiment 1 (of Study1) and Experiment 2 (of Study 2) due to different periods of each study performed as in Table 3.

Table 3 Ranges of the scores for low and high groups of GSS1 and GSS2 of Study1 and Study2, N = numbers of participants in each group

Varia-bles	GSS1						GSS2					
	Study1			Study2			Study1			Study2		
	N	Low	High	N	Low	high	N	low	high	N	Low	high
Yield1	7	0-3	5-7	6	2-3	6-8	8	0-1	2-10	7	0-2	3-7
Yield2	7	0-3	6-9	6	3-4	6-10	6	0-2	6-14	6	0-4	6-14
Shift	7	0-1	4-7	6	0-3	4-7	7	0-1	4-8	6	0-3	5-10
TS	7	0-4	9-13	6	3-9	10-15	7	0-3	8-15	6	0-5	6-14
Im-Recall	7	12-21	23-28	6	15-20	22-29	7	16-26	29-32	6	18-26	27-35
De-Recall	7	10-20	25-34	6	13-21	24-31	7	19-25	28-36	7	22-26	29-34
DRM-Free recall	7	121-136	147-192	6	103-153	157-178	7	93-137	153-181	7	131-149	152-177
DRM Correc recog[1]	7	12-17	21-24	6	31-38	40-45	7	14-18	20-23	6	26-38	41-47
DRM-FA[2]	8	2-10	12-16	6	4-6	14-15	7	2-8	12-16	7	3-5	14-16
FA-odd[3] (%)	7	0-4.5	9.10-18.2	6	0-4.5	9.10-27.3	7	0-4.5	9.10-22.7	7	0	4.5-27.3

[1] DRM Correct recognition; participants correctly circled “old” as “old” words in the DRM questionnaire
[2] DRM-False Alarm; participants incorrectly circled “new” as “old” words in the DRM questionnaire
[3] False Alarm-oddball; participants incorrectly pressed “new (irrelevant)” as “old (relevant)” conditions

ERP data analyses for Study 1 and Study 2

ERP data were analyzed offline using the Brain Vision Analyzer software version 1.05). The sampling rate was set at 256 Hz, and EEG signals were re-referenced to linked mastoids and filtered within a .01 to 30 Hz bandwidth. After segmentation of EEG data into 4 categories – old/old (correct recognitions), old/new (misses), new/new (correct rejections), and new/old (incorrect recognitions, or false alarms), eye-movement correction was applied using the method of Gratton and Coles (Gratton, Coles, & Donchin, 1983), followed by baseline correction, and finally artefact rejection. Artefact rejection criteria comprised a maximum allowed voltage step (50 uV), amplitude criterion (+/- 80 μV), maximum allowed absolute difference (200 uV) and lowest allowed activity (max-min) was 0.5 uV in any 100 ms interval. The ERPs were then averaged by channel and segmentation category from 500 ms pre-stimulus to 1500 ms post-stimulus, a total epoch of 2 seconds. Grand averages and topographical maps were generated using all 32 channels.

The same procedure for ERP measurement was used for Studies 1 and 2. Therefore, all low score groups of participants from Studies 1 and 2 and all high score groups of participants from Studies 1 and 2 were collapsed and analyzed as one study.

Altogether, GSS1 had 37 participants (7 males) and GSS2 had 47 participants (12 males) after ten participants were excluded due to only a few segments left in the conditions. Two participants (all males), one from GSS1 and one from GSS2 were left-handed.

The minimum acceptable number of error-free and artefact-free trials per participant was set at 10 for conditions 2 and 3, and 100 for condition1. The mean numbers of trials accepted per condition and per participant were: for conditions 2 and 3, 12.71 and 13.99 respectively; for condition 1, 130.

For ERP measurement, error free and artefact free trials that were accepted for averages in each condition, separated by each variable for GSS1 and GSS2 are shown in Table 4.

Table 4 Numbers of trials that were used for ERP averages in each condition

Variables	GSS	Group	N	Condition	Range	Mean (SE)
All participants	1	All	37	1 2 3	100-175 10-20 10-22	128.97(4.12) 13.16(.51) 14.03(.59)
	2	All	47	1 2 3	100-175 10-20 10-20	131.06(3.79) 12.36(.42) 13.96(.56)
Female	1	All	30	1 2 3	100-174 10-20 10-20	125.37(4.35) 12.67(.57) 13.40(.59)
	2	All	35	1 2 3	100-169 10-20 10-20	129.77(4.37) 12.31(.50) 13.91(.67)
Male	1	All	7	1 2 3	100-175 13-19 11-22	144.43(9.83) 15.29(.84) 16.71(1.55)
	2	All	12	1 2 3	100-175 10-18 10-20	134.83(7.80) 12.50(.84) 14.08(1.09)
TS	1	Low	13	1 2 3	100-154 10-20 10-20	133.54(5.77) 13.77(1.05) 14.77(1.03)
		High	13	1 2 3	100-164 10-16 10-17	114.54(5.93) 11.69(.56) 12.00(.61)
	2	Low	13	1 2 3	100-168 10-17 10-20	135.92(7.19) 12.38(.80) 13.69(1.08)
		High	13	1 2 3	100-162 10-20 10-20	125.46(6.90) 12.54(.96) 13.92(1.12)
Immediate Recall	1	Low	13	1 2 3	100-164 10-20 10-17	114.54(6.60) 12.15(.87) 12.38(.75)
		High	13	1 2 3	100-174 10-20 10-20	135.92(5.91) 13.08(.94) 14.77(.96)
	2	Low	13	1 2 3	100-169 10-16 10-20	118.15(6.75) 11.46(.62) 13.15(1.08)
		High	13	1 2 3	100-168 10-18 10-20	135.92(6.11) 13.23(.83) 14.54(1.04)

Table 4 (continued)

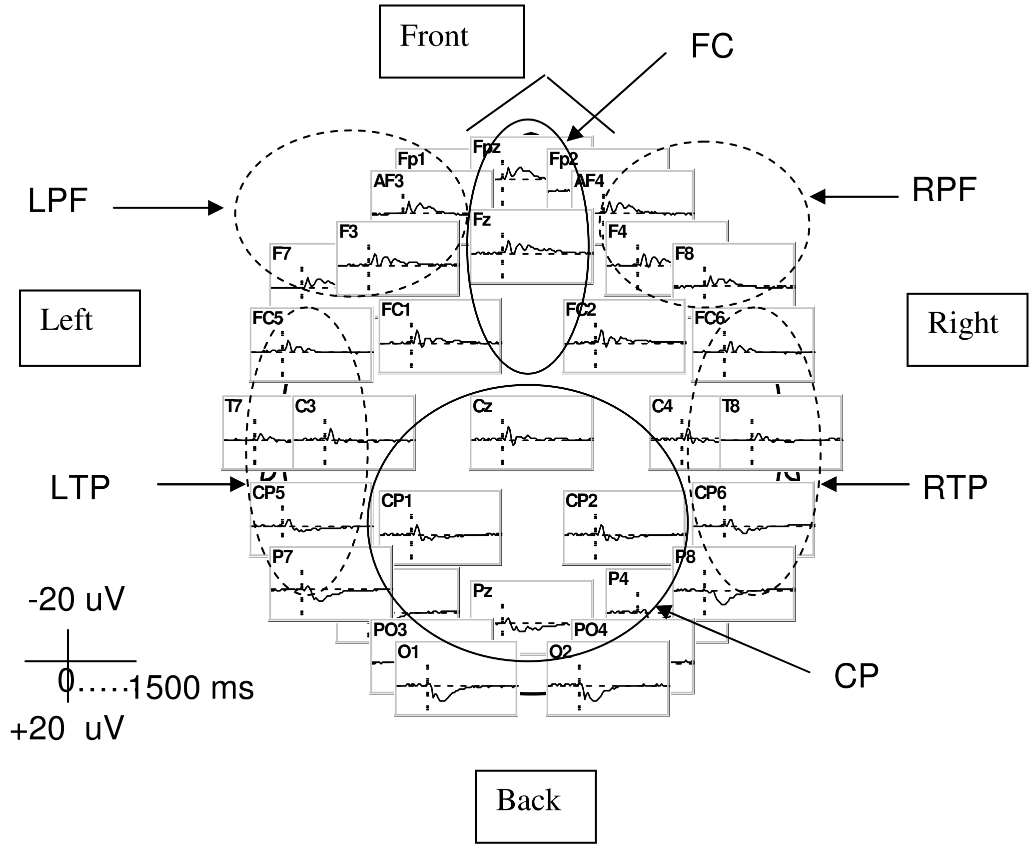
Variables	GSS	Group	N	Condition	Range	Mean(SE)
DRM-free recall (Recall word)	1	Low	13	1 2 3	100-151 10-20 10-19	123.54(6.07) 14.15(.99) 13.92(.85)
		High	13	1 2 3	100-174 10-17 10-20	130.38(7.47) 11.85(.67) 13.23(.99)
	2	Low	14	1 2 3	100-164 10-16 10-20	125.79(6.25) 11.29(.54) 13.86(1.06)
		High	14	1 2 3	100-169 10-20 10-20	139.57(7.18) 13.64(.91) 15.00(1.04)
DRM-FA	1	Low	14	1 2 3	100-154 10-20 10-20	127.86(5.67) 12.36(.91) 13.71(.97)
		High	14	1 2 3	100-174 10-20 10-17	126.50(7.11) 13.36(.77) 13.57(.75)
	2	Low	14	1 2 3	100-169 10-18 10-20	142.79(6.33) 12.64(.80) 16.14(1.12)
		High	14	1 2 3	100-168 10-20 10-16	121.43(6.57) 12.14(.86) 12.00(.51)
FA(oddball)	1	Low	13	1 2 3	100-174 10-17 10-20	127.69(7.04) 11.92(.64) 13.77(.91)
		High	13	1 2 3	100-164 10-20 10-19	120.85(6.48) 13.46(1.07) 13.08(.89)
	2	Low	14	1 2 3	100-169 10-18 10-20	127.50(6.91) 11.64(.72) 15.21(1.21)
		High	14	1 2 3	100-168 10-20 10-20	127.29(7.12) 12.79(.89) 12.71(.79)

The scalp was partitioned, on the basis of a preliminary inspection of ERPs and topographical maps as critical time windows of old-new differences into seven regions of interest and three intervals, 250-350 ms, 350-700ms and 700-1100 ms. In addition, the epochs were defined by visual inspection of peaks according to the overall ERP graphs to see attention effects. As for the old/new effects following Meclinger's (2000) neurocognitive model, the intervals were adjusted partly to cover the amplitudes (N400, P3) of the present ERPs. Fz was the representative of the frontal old/new effects, Pz was the representative of the parietal old/new effects, and F8 was the representative of the right frontal old/new effects. Therefore, the epochs and scalp partitions were defined as follows:

ERP component	Interval Windows (ms)
N100	81-130
P200	131-210
N200	211-320
P300	321-500
Frontal old/new effect	300-600
Parietal old/new effect	400-800
Right frontal old/new effect	800-1450
Orbitofrontal (OF : Fp1, Fpz, Fp2)	250-350, 350-700, 700-1100
Right Prefrontal (RPF: FP2, AF4, F4 and F8)	250-350, 350-700, 700-1100
Left Prefrontal (LPF: FP1, AF3, F3 and F7)	250-350, 350-700, 700-1100
Right Temporo-parietal (RTP: FC6, T8, CP6 and P8)	250-350, 350-700, 700-1100
Left Temporo-parietal (LTP: FC5, T7, CP5 and P7)	250-350, 350-700, 700-1100
Fronto-central (FC: Fpz, Fz, FC1 and FC2)	250-350, 350-700, 700-1100
Centro-parietal (CP: Cz, CP1, CP2 and Pz)	250-350, 350-700, 700-1100

Figure 4 shows the montage and the regions of interest.

Figure 4 Montage for EEG recordings, with grand average of Condition 1 (N = 30, female participants who underwent GSS1).



ERP analyses of memory

There were several phases of data analysis. Data for error trials (false recognitions and false rejections) were discarded due to a small number of trials.

In a preliminary phase of data analysis, a four-factor repeated ANOVA (2 Condition x 7 region x 2 SEX x 2 GSS) on mean amplitudes of corresponding regions (LPF, OF, RPF, LTP, RTP, FC, and CP) at 250-350 ms, 350-700 ms and 700-1100 ms intervals were performed by using SEX and GSS as between-subject variables to examine the effects of SEX (male, female) and GSS (GSS1, GSS2). Then, those individuals with extreme suggestibility and extreme memory performance were classified into low and high groups of IS and their memory performance, respectively, based on their frequency curves to compare the results in each region and interval of interest using (2 Condition x 2 GSS x 2group; low vs. high) ANOVAs. Finally, paired t-tests were performed as post-hoc analyses for old/new difference effects. Only females were included in the group, due to a small number of male participants. In addition, males and females showed different results for GSS memory recall as shown later in Chapter 3.

As for ANOVA analyses, Geisser-Greenhouse corrections were employed and the corrected probabilities were reported when appropriate. However, the degrees of freedom that were reported were uncorrected degrees of freedom to make data comparable.

ERPs analyses of memory following Mecklinger's (2000) model

Early frontal (Fz, 300-600 ms), parietal (Pz, 400-800), and late right (pre)frontal (F8, 800-1450 ms) old/new ERP effects were examined. These time windows were suggested by Mecklinger (2000)'s model as relating to memory recognition effects; however, they were adjusted partly for appropriateness as already mentioned.

(2 Condition x 2 GSS x 2 group) ANOVAs were performed at each old/new effect separately and paired t-tests were used as post-hoc analyses.

ERPs analyses of attention

(3 Condition x 2 GSS x 2 group) ANOVAs were performed on peak amplitudes as well as mean amplitudes of three conditions (distracters, story relevant, story-irrelevant) at each epoch pertaining to attention of low and high groups of IS.

Having outlined the methodology of the investigation, the next chapter (Chapter 3) will present results pertaining to cognitive performance in the memory tasks, behavioral performance in the GSS, and task performance in the oddball task (Result 1). Chapter 4 will present results pertaining to personality correlates of IS and memory

(Result 2). The following two chapters (Chapters 5 and 6) will present results pertinent to the underlying neurocognitive mechanisms of IS, in terms of memory and attention, respectively (Results 3 and 4). Chapter 7 will provide a general discussion of the results.

Chapter 3

Result 1: Memory and Task Performance

As outlined in Chapter 1, one aim of this investigation was to explore relationships between IS and memory performance, using a variety of memory measures and paradigms. The oddball paradigm used here can itself be considered a memory measure, insofar as it tested participants' memory indirectly. Specific questions addressed in relation to memory and task performance measures were:

1. Do GSS1 and GSS2 give equivalent results on the various measures of memory, IS, and related variables? Are they comparable to the norms presented by Gudjonsson (1997)?
2. Do male and female participants give equivalent results on the various measures of memory, IS, and related variables?
3. What are the relationships between measures of IS- i.e., Yield1, Yield2, Shift, and TS (GSS1 and GSS2) and the yield measure from the PEMQ?
4. What are the relationships between the various measures of Memory – i.e., recognition (DRM; old, new), free recall (DRM, GSS immediate recall and delayed recall) and false alarm (oddball and DRM)?
5. What are the relationships between memory measures and IS measures?

<u>Hypotheses</u>

According to the specific questions above, the respective hypotheses can be generated as follows.

1. GSS1 and GSS2 are likely to give equivalent results on the various measures of memory, and related variables. This is due to the fact that both versions of GSS scales were developed to be parallel or equivalent and Gudjonsson also shows that both versions yield the same statistics results. However, they might not be comparable to the norms presented by Gudjonsson (1997). This is due to different subjects or culture can produce different results. Gudjonsson (1997) conducted the study with subjects in western culture, while this study was conducted in Singapore.

2. Males and female participants are likely to give equivalent results on the various measures of IS, and related variables. This is because most of the studies related to IS did not find significantly different results between males and females (e.g. Gudjonsson, 1997). As for memory and related variables, females should outperform males in verbal memory tasks (e.g. Lowe, Mayfield, and Reynolds, 2003).

3. The correlations between measures of IS (Yield1, Yield2, Shift, and TS) and the Yield measures of the PEMQ are likely to be positive. This is because the misleading questions of the PEMQ should be analogous to the Yield measures of GSS scales (Eisen, et al., 2002). However, the correlation between the Shift score of the GSS and the misleading questions of the PEMQ should not be high because the Shift score and the Yield or misleading questions of the PEMQ are somewhat independent.

4. The relationships between the various measures of memory and false alarm (oddball and DRM) are likely to be negatively correlated. Participants who have good memory tend to make fewer false alarms in whichever measures. In addition, the correlations between DRM-free recall and GSS-free recall (immediate and delayed recalls) are likely to be more positive than those of DRM-recognition (old, new) and

GSS-free recall. This is because within-measure (free-recall and free-recall) is likely to have more positive correlations than between-measure (recognition and free recall).

5. The relationships between memory and IS measures are likely to be negatively correlated. People who have poor memory tend to yield more to leading questions, and vice versa. Furthermore, people who have poor memory tend to shift their answers more.

In this chapter, results are presented following the steps of questionnaires that were administered to the entire participants (N=405) and narrow down to the results from GSS scales. The correlations of separate males and females, and combined males and females yielded the similar results; therefore, males and females were collapsed as one group in correlation studies. However, interpreting the results should be done with care because a large number of correlational analyses were conducted in which type I error may be increased. Nonetheless, there was cohesion among the results as well as results from previous studies.

To show the results, first, descriptive statistics, including factor analyses of the entire data are presented. Second, intercorrelations of overall results and factor analyses of Study 1 are presented (Factor analyses of Study 2 are not shown here due to no PEMQ data for Study 2), Third, overall data are compared between males and females by using independent t-tests to explore differences. In addition, intercorrelations between the overall results are shown separately for males and females to show that males and females yielded similar results of correlation studies. Fourth, results of GSS and DRM measures compared GSS1 and GSS2 are presented, broken down by sex to explore differences. Fifth, intercorrelations between GSS variables and other variables are presented, separately for GSS1 and GSS2, and finally GSS1 and GSS2 collapsed for a whole picture. Finally, oddball performance between GSS1& GSS2, males & females, and low & high groups of IS and memory measures are presented to see the whole picture. There will follow a brief discussion relating to the above questions being asked.

Memory and IS

As reviewed in chapter 1, a large number of studies have shown that IS correlates significantly and inversely with memory scores. In other words, the better the subjects' memory, the less suggestible the subjects are likely to be. Gudjonsson (1988a) found that the verbal recall score of the GSS1 and GSS2 correlated negatively with IS. The magnitude of the correlation between memory on the GSS and Interrogative Suggestibility is similar to that of IQ and IS (Gudjonsson & Clare, 1995). Correlations between memory and IS of between -0.5-0.6 are typically found for normal subjects. The correlations are much lower among forensic patients than normal subjects (Gudjonsson, 1988a).

However, Bruck and Melnyk argued that the correlations between memory and suggestibility may reflect context-specific factors rather than cognitive factors because some studies were found that memory in one setting was not a good predictor of suggestibility in a second setting. Therefore, correlations of interrogative suggestibility and various measures of memory were explored and shown in this chapter.

Memory and Oddball task performance measure

The Oddball task allowed participants to press "old or relevant to the story" and "new or irrelevant to the story". As a result, participants produced reaction time, performance accuracy for hits (old press old), correct rejections (new press new), misses (old press new), and false alarms (new press old). The Oddball False Alarm should be analogous to the DRM False Alarm. As such, participants who tend to make more false alarms in whichever measures should have poorer memory performance, when compared to participants who make fewer false alarms.

Results: Memory, IS, and Oddball task performance measure

The DRM paradigm produces the scores of "Old" which means participants correctly circled old (already heard) words as "old", "New" which means participants correctly circled new (never heard from the tape player) words as "new", and "False Alarm (FA)" which means participants misclassified "critical lure words" (never heard) as "old". In addition, it also gives "DRM free recall or Recall word (RW)" which were counted from the words that participants could recall correctly.

Overall results: DRM, GCS, and PEMQ

The descriptive statistics results of the variables are as follows.

Table 5 Descriptive statistics of the variables

Score	N	Total score	Minimum	Maximum	Mean	SD
DRM-FA	405	16	0	16	10.06	3.66
New	395	32	16	32	29.31	3.19
Old	404	48	24	48	38.43	4.69
GCS	405	20	1	20	10.30	3.75
Recall word (DRM)	405	240	93	205	150.29	19.49
Misleading (PEMQ)	204*	22	2	14	7.88	2.33
Specific Question (PEMQ)	204*	20	10	20	15.33	1.75
Repeated Question (PEMQ)	203*	4	0	1	.10	.31

*only Study 1

A factor analysis was applied to the variables above (replace missing data and outliers with means). There were 3 factors. Factor1 comprised New and FA (in opposite direction). Factor2 comprised Old and Recall word. Finally, Factor3 comprised GCS (see Table 6).

Table 6 Rotated Component Matrix of the variables (N=405)

Variable	MSA*	Factor		
		1	2	3
New	.53	**.80**	.04	.09
FA	.50	**-.79**	.03	.09
Old	.40	-.31	**.85**	.07
Recall word	.41	.32	**.84**	-.07
GCS	.28	.01	.001	**.99**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .44
*MSA = Measures of Sampling Adequacy

Barlett's Test of Sphericity has a significance level less than .001. This indicates that the data is probably factorable. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy is 0.44 which is poor. This indicates that the factor analysis should not be conducted.

All pearson correlations reported are two-tailed significance. Pearson correlations for the variables are shown in Table 7.

Table 7 Pearson correlations between the variables (N=405 unless specified in parentheses)

Variable	New	Old	Recall word	GCS	Mislead# (PEMQ)	Specific# Question	Repeated# Question
DRM-FA	-.32*** (395)	.20*** (404)	-.19***	.03	-.007 (204)	-.11 (204)	.01 (203)
New	-	-.16** (394)	.20* (395)	.03 (395)	-.01 (199)	.10 (199)	.02 (198)
Old	-	-	.43*** (404)	.04 (404)	.02 (203)	-.02 (203)	-.01 (202)
Recall word (DRM)	-	-	-	-.04	.07 (204)	.14 (204)	.03 (203)
GCS	-	-	-	-	.10 (204)	-.07 (204)	.05 (203)
Misleading (PEMQ)	-	-	-	-	-	.06 (204)	.18* (203)
Specific question	-	-	-	-	-	-	-.12 (203)

*p<.05,**p<.01,***p<.001, # = only Study 1

DRM-FA had negative correlations with New and Recall word variables (r= -.32, p<.001, and r= -.19, p<.001, respectively). In other words, participants who tended to make DRM-FA (treating new as old words) could recall fewer words than participants who had low false alarm. The preceding results are due to the fact that DRM-FA is the tendency to treat new words as old words; therefore, participants who have high DRM-FA scores will have low new word scores. Participants who have low DRM-FA scores will have high new word scores, and have more recall word scores because they have better memory capacity than high DRM-FA individuals. However, the correlations between DRM-FA scores and Old word scores are positive because DRM-FA is the tendency to circle OLD. The more they circle OLD, the more they make false alarms. In addition, the questionnaires have only two choices, OLD or NEW. If participants have high OLD scores, they have automatically low NEW scores (an opposite direction). These are the reasons for having negative correlations between OLD & NEW scores, positive correlations between OLD & DRM-FA scores, and negative correlations between NEW & DRM-FA scores. There were significant correlations between New and Recall word scores ($r=.20$, $p<.05$) and Old and Recall word scores ($r=.43$, $p<.001$). This again indicates that participants who have good recognition memory will also have good recall memory.

The misleading questions which were claimed to be analogous to Yield of the GSS scales had a small but significant correlation ($r=.18$, $p<.05$) with the repeated questions which are claimed to be analogous to Shift of the GSS scales (Eisen et al., 2002). This indicates that individuals who yielded to the misleading questions tended to shift their answers when asked the repeated question. However, the misleading questions, the specific questions and the repeated questions of the PEMQ in this study had no significant correlations with the other variables.

There were significant correlations between New and New2 ($r=.21$, $p<.01$) and Old and Old2 ($r=.33$, $p<.001$) and FA and FA2 ($r=.46$, $p<.001$). (The results were not shown in the table. This indicates that there were significant (albeit low) test-retest reliabilities of Old, New and FA memory of the two forms of the DRM questionnaire within individuals because the R1 and R2 forms of the DRM questionnaire were administered one week apart. The results shown here were doubled scores of Old, New, DRM-FA of the form (R1 or R2) that was used in the first session for Study 1. For Study 2, the two forms were collapsed as one form. The reasons to do this have been already mentioned in Chapter 2).

Table 8 shows the results of a factor analysis for the variables of Study 1. A comparable factor analysis was not conducted for Study 2 because the PEMQ procedure was not administered in Study 2. Data for males and females are combined.

Table 8 Rotated Component Matrix of Study 1 variables (N=204)

Variable	MSA*	Factor			
		1	2	3	4
DRM-FA	.48	**-.78**	-.04	.03	-.06
New	.57	**.76**	-.04	.02	.01
Old	.40	-.31	**.83**	-.03	-.07
Recall word (DRM)	.43	.34	**.82**	.03	.12
Repeated question (PEMQ)	.47	.02	.11	**.67**	-.20
Misleading (PEMQ)	.49	-.08	.01	**.66**	.54
GCS	.47	.01	-.08	**.55**	-.07
Specific question (PEMQ)	.55	.11	.03	-.25	**.84**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
Kaiser-Meyer-Olkin Measure of Sampling Adequacy = .46
*MSA = Measures of Sampling Adequacy

There were four factors. Factor 1 comprised DRM-FA and New (in opposite direction). Factor 2 comprised Old and Recall word. Factor 3 comprised Misleading question, Repeated question of the PEMQ and GCS. Finally, Factor 4 comprised Specific question scores of the PEMQ. The factor analysis appeared to yield a “suggestibility or compliance” factor (Factor 3).

Results for DRM and GCS compared males and females

Memory and IS variables were compared between males and females. The numbers of participants are not equal in each variable due to dropped outliers. The results are shown in Table 9.

Table 9 Means and standard errors of males and females for memory and suggestibility variables

Variable	Sex	N	Range	Mean (SE)	t-test
DRM-FA	F	317	0-16	9.89(.21)	t(403)= -1.83, p<.07
	M	88	0-16	10.69(.38)	
Old	F	316	24-48	38.35(.27)	
	M	88	24-48	38.73(.49)	
New	F	312	16-38	29.64(.16)	t(105.41)*= 2.86, p<.01
	M	85	16-33	28.26(.46)	
GCS	F	317	1-20	10.40(.21)	
	M	88	4-19	9.94(.41)	
DRM-free	F	317	93-205	151.45(1.08)	t(403)= 2.29, p<.05
recall (RW)	M	88	102-205	146.10(2.13)	

*df for an unequal variance

Males had marginally more DRM-FA than females. Females had more “New” word Recognition and DRM-free recall than males. These mean that females had better memory than males and males tended to make more false alarms to lure than females.

Pearson correlations for females and males of the variables were analyzed separately. The results are shown in Table 10 and 11, respectively. The number of participants was not equal due to dropped outliers.

Table 10 Pearson correlations between the variables of females (N=317 unless specified in parentheses)

Variable	New	Old	GCS	Recall word
DRM-FA	-.31*** (311)	.19*** (316)	.02	-.14*
New	-	-.17** (310)	.00 (311)	.13* (311)
Old	-	-	.02 (316)	.47*** (316)
GCS	-	-	-	-.08

*p<.05,**p<.01,***p<.001

Table 11 Pearson correlations between the variables of males (N=88 unless specified in parentheses)

Variable	New	Old	GCS	Recall word
DRM-FA	-.36***(84)	.22*	.11	-.32**
New	-	-.12 (84)	.06 (84)	.32** (84)
Old	-	-	.13	.32**
GCS	-	-	-	.08

*p<.05,**p<.01,***p<.001

The overall correlation results of males and females are more or less the same (albeit lower statistical power in males). DRM-FA had negative correlations with New and Recall word (DRM-free recall) variables. In other words, participants who tended to make false alarm (treating new as old words) could recall fewer words than participants who had low false alarm.

DRM, GSS suggestibility and memory, compared between GSS1 & GSS2, males & females

Descriptive statistics compared between GSS1 and GSS2 and separately for males and females are shown in Table 12.

Table 12 GSS and DRM behavioural measures, data are shown for collapsed and separate males and females (#=significant difference between males and females within each GSS)

GSS & DRM	GSS1 (n=43, 8 males)		GSS2 (n=51, 12 males)		t-test between GSSs
Measure	Range	Mean(SE)	Range	Mean(SE)	
Yield1	0-8	**4.07(.33)**	0-10	**2.78(.31)**	t(92)=2.86, p<.01
Female	0-8	**4.17(.36)**	0-10	**2.54(.34)**	t(72)=3.28, p<.01
Male	0-6	3.63(.80)	0-7	3.58(.66)	
Yield2	0-10	5.07(.43)	0-14	5.06(.54)	
Female	0-10	5.11(.50)	0-14	4.64(.61)	
Male	1-9	4.88(.91)	0-10	6.42(1.12)	
Shift	0-8	3.14(.37)	0-11	3.47(.41)	
Female	0-8	3.26(.41)	0-11	3.46(.49)	
Male	0-8	2.63(.92)	0-7	3.50(.72)	
TS	0-15	7.21(.59)	0-15	6.35(.62)	
Female	0-15	7.43(.69)	0-15	6.13(.73)	
Male	1-10	6.25(1.06)	0-12	7.08(1.16)	
Im-Recall	12-38	**22.00(.72)**	9-35	**25.94(.85)**	t(92)= -3.48, p<.01
Female	12-38	**22.06(.84)**	12-36	**27.08(.84)#**	t(71)= -4.87,p<.001
Male	18-29	21.75(1.28)	9-30	**22.25(2.05)#**	#t(49)=2.55,p<.05
De-Recall	10-34	**22.53(.84)**	11-36	**25.98(.77)**	t(95)=-2.88, p<.01
Female	10-34	**22.60(.95)**	17-36	**26.82(.75)#**	t(74)= -3.5,p<.01
Male	17-33	22.25(1.92)	11-33	**23.25(2.06)#**	#t(49)=2.03,p<.05
FA(oddball)	0-27.30	8.42(1.14)	0-27.30	10.37(1.24)	
Female	0-27.30	8.16(1.19)	0-27.30	**9.20(1.36)(#)**	(#)t(47)=-1.7, p<.10
Male	0-22.70	9.73(3.63)	0-27.30	**14.00(2.65)(#)**	
DRM-FA	0-16	10.21(.64)	2-16	10.14(.67)	
Female	2-16	10.06(.69)	2-16	**9.62(.76)(#)**	(#)t(49)=-1.41, p<.17
Male	0-15	11.33(1.59)	2-16	**11.83(1.41)(#)**	

Solid figures show significant differences.

Table 12 (continued)

GSS & DRM	GSS1 (n=43, 8 males)		GSS2 (n=51, 12 males)		t-test between GSSs
Measure	Range	Mean(SE)	Range	Mean(SE)	
RW (DRM)	103-192	148.95(2.71)	93-181	146.37(2.76)	
Female	103-192	148.83(3.19)	93-181	147.13(3.01)	
Male	138-177	149.50(4.49)	107-176	143.92(6.70)	

For the overall results, GSS1 showed lower immediate and delayed recall than GSS2 and GSS1 showed higher yield1 than GSS2 in which females contributed more for the effects. The delayed recall scores were slightly higher than the immediate recall scores because in these experiments, participants had to see the stimulus pictures for ERP measurement before they did the delayed recall. The pictures allowed participants to rehearse the content of the story between immediate and delayed recall.

In this study, males and females were significantly different only in immediate recall and delayed recall of GSS2. Females showed superior immediate and delayed recall to males. However, males tended to show more FA (DRM and oddball) than females in GSS2. This is consistent with those of Table 9 which showed that females had more New and DRM-free recall than males, and males tended to show more DRM-FA than females.

<u>Intercorrelations for IS and memory</u>

The correlation results of GSS1 and GSS2 separately are shown in the Table 13 and 14, respectively.

Table 13 Pearson correlations between the variables of GSS1 (N=43, unless specified in parentheses), # = only Study 1, *p<.05, **p<.01, ***p<.001

Variable	DRM-FA	New	Old	GCS	Yield1	Yield2	Shift	TS	Im-Recall	De-Recall	Recall Word	Mislead# question	Repeat# question	Specific# Question
FA oddball	.48** (42)	-.26 (39)	-.02 (42)	.08 (41)	.23 (42)	.06 (42)	-.02 (42)	.11 (42)	-.35* (42)	-.29 (42)	-.38* (42)	-.29 (24)	.12 (24)	.08 (24)
DRM-FA	-	-.38* (40)	.11	.22	.19	.19	.07	.15	-.24	-.24	-.41**	.05 (25)	.01 (25)	-.08 (25)
New	-	-	-.28 (40)	-.07 (40)	-.07 (40)	-.20 (40)	-.16 (40)	-.14 (40)	.07 (40)	.05 (40)	.25 (40)	-.32 (21)	.15 (21)	.31 (21)
Old	-	-	-	.13	.15	.08	.20	.21	.002	.10	-.01	.35 (25)	-.26 (25)	.11 (25)
GCS	-	-	-	-	.10	-.05	-.07	.01	.01	-.05	-.33*	.25 (25)	-.08 (25)	-.05 (25)
Yield1	-	-	-	-	-	.65***	.44**	.83***	-.58***	-.47**	-.24	.36 (25)	.11 (25)	-.15 (25)
Yield2	-	-	-	-	-	-	.65***	.76***	-.49**	-.48**	-.06	.32 (25)	.12 (25)	-.14 (25)
Shift	-	-	-	-	-	-	-	.87***	-.10	-.04	.08	.46* (25)	.20 (25)	-.11 (25)
TS	-	-	-	-	-	-	-	-	-.38*	-.29	-.08	.48* (25)	.18 (25)	-.15 (25)
Im-Re	-	-	-	-	-	-	-	-	-	.78***	.47**	-.13 (25)	-.17 (25)	.05 (25)
De-Re	-	-	-	-	-	-	-	-	-	-	.52***	-.03 (25)	-.17 (25)	.09 (25)
Recall word	-	-	-	-	-	-	-	-	-	-	-	.05 (25)	-.10 (25)	.23 (25)
Mislead	-	-	-	-	-	-	-	-	-	-	-	-	.08 (25)	.12 (25)
Repeat	-	-	-	-	-	-	-	-	-	-	-	-	-	-.19 (25)

For GSS1, DRM-FA had no correlations with Yield1, Yield2, Shift and TS. Not surprisingly, Yield1 had negative correlations with immediate recall and delayed recall ($r= -.58$, $p<.001$ and $r= -.47$, $p<.01$, respectively). This indicates that individuals who tend to yield to leading questions had poor memory recall. In addition, GCS had a negative correlation with Recall word ($r= -.33$, $p<.05$). This means that individuals who have low capacity of word recall memory tend to show high compliance.

FA(oddball), participants mistakenly pressed OLD for NEW pictures in the oddball task, had negative correlations with memory recall (both GSS and DRM) and also had a positive correlation with FA from DRM (circle New words as Old words). These results of FA(oddball) were consistent with those of DRM-FA.

For GSS1, Misleading questions from the PEMQ had positive correlations with Yield1 ($r=.36$, $p<.09$), Shift ($r=.46$, $p<.05$), and TS ($r=.48$, $p<.05$). This is consistent with Eisen et al. (2002)'s hypothesis that misleading questions are analogous to Yield1 scores (albeit marginally significant).

Table 14 Pearson correlations between the variables of GSS2 (N=51, unless specified in parentheses), # = only Study 1, *p<.05, **p<.01, ***p<.001

Variable	DRM-FA	New	Old	GCS	Yield1	Yield2	Shift	TS	Im-Recall	De-Recall	Recall Word	Mislead# question	Repeat# question	Specific# Question
FA Oddball	.22 (49)	-.07 (47)	.24 (49)	-.02 (49)	.09 (49)	.06 (49)	.09 (49)	.11 (49)	-.06 (49)	-.01 (49)	.06 (49)	.17 (23)	-.11 (23)	.12 (23)
DRM-FA	-	-.63*** (49)	.29*	-.05	.39**	.29*	.20	.34*	-.39*	-.32*	-.38**	-.01 (23)	.06 (25)	.11 (25)
New	-	-	-.15 (49)	.10 (49)	-.21 (49)	-.21 (49)	-.09 (49)	-.18 (49)	.48** (49)	.47** (49)	.49*** (49)	-.05 (24)	-.51* (24)	.11 (24)
Old	-	-	-	-.04	.13	.05	.06	.09	.06	.12	.43**	.25 (25)	.04 (25)	.13 (25)
GCS	-	-	-	-	-.02	.20	.27	.13	-.004	-.11	-.10	.19 (25)	-.09 (25)	-.15 (25)
Yield1	-	-	-	-	-	.72***	.38**	.77***	-.45**	-.36*	-.10	.07 (25)	-.04 (25)	.01 (25)
Yield2	-	-	-	-	-	-	.81***	.93***	-.43**	-.43**	-.19	.20 (25)	-.04 (25)	-.01 (25)
Shift	-	-	-	-	-	-	-	.86***	-.19	-.20	-.15	.23 (25)	-.01 (25)	.04 (25)
TS	-	-	-	-	-	-	-	-	-.40**	-.35*	-.18	.12 (25)	-.05 (25)	-.03 (25)
Im-Re	-	-	-	-	-	-	-	-	-	.87***	.50***	-.01 (25)	-.25 (25)	.30 (25)
De-Re	-	-	-	-	-	-	-	-	-	-	.53***	-.04 (25)	-.35 (25)	.17 (25)
Recall Word	-	-	-	-	-	-	-	-	-	-	-	.25 (25)	-.19 (25)	.23 (25)
Mislead	-	-	-	-	-	-	-	-	-	-	-	-	.38 (25)	.15 (25)
Repeat	-	-	-	-	-	-	-	-	-	-	-	-	-	.07 (25)

For GSS2, DRM-FA had positive correlations with Yield1, Yield2 and TS ($r=.39$, $p<.01$, $r=.29$, $p<.05$, $r=.34$, $p<.05$ respectively). Yield1 had negative correlations with immediate recall and delayed recall ($r= -.45$, $p<.01$ and $r= -.36$, $p<.05$, respectively). This indicates that individuals who tend to yield to leading questions have poor recall memory. However, the significant correlation between Yield1 and Recall word was not found. FA(oddball) had no significant correlation with all variables, only tended to have a correlation with DRM-FA, $r=.22$. However, there were no significant correlations between PEMQ measures and GSS measures except for the marginal correlation between the PEMQ Repeated measure and the GSS Delayed recall ($r= -.35$, $p<.09$). There was also a significant negative correlation between NEW and repeated questions, $r= -.51$, $p<.05$). These indicate that participants who tended to shift their answers had lower memory (recall or recognition) capacity.

For both GSS1 and GSS2, there were no significant correlations between Yield1 from GSS scales and Recall word (DRM-free recall) from the DRM paradigm. However, Yield1 tended to have a negative correlation with Recall Word in GSS1, $r= -.24$.

Pearson correlations for collapsed GSS1 and GSS2 of the overall studies are shown in Table 15.

Table 15 Pearson correlations between the variables of collapsed GSS1 and GSS2 (N=94 unless specified in parentheses), #=only Study1,
*p<.05, **p<.01, ***p<.001

Variable	DRM -FA	New	Old	GCS	Yield1	Yield2	Shift	TS	Im-Recall	Delayed Recall	Recall Word	Mislead# question	Repeat# question	Specific# question
FA Oddball	.30** (91)	-.13 (86)	.12 (91)	.04 (90)	.08 (91)	.05 (91)	.03 (91)	.06 (91)	-.07 (91)	-.08 (91)	-.13 (89)	-.10 (47)	.17 (47)	.01 (47)
DRM-FA	-	-.53*** (89)	.21*	.03	.30**	.26*	.15	.27*	-.31**	-.28**	-.38***	.03 (48)	.03 (50)	.07 (50)
New	-	-	-.22* (89)	.03 (89)	-.09 (89)	-.20 (89)	-.13 (89)	-.14 (89)	.25** (89)	.23* (89)	.40*** (89)	-.003 (45)	-.06 (45)	.16 (45)
Old	-	-	-	.04	.10	.06	.12	.13	.10	.14	.22*	.26 (50)	-.10 (50)	.09 (50)
GCS	-	-	-	-	-.01	.15	.20	.10	.06	-.06	-.16	.23 (50)	-.10 (50)	-.03 (50)
Yield1	-	-	-	-	-	.66***	.37***	.79***	-.53***	-.46***	-.15	.24 (50)	.00 (50)	.03 (50)
Yield2	-	-	-	-	-	-	.75***	.86***	-.42***	-.42***	-.16	.26 (50)	.02 (50)	-.01 (50)
Shift	-	-	-	-	-	-	-	.85***	-.10	-.11	-.09	.33* (50)	.08 (50)	.00 (50)
TS	-	-	-	-	-	-	-	-	-.38***	-.33**	-.16	.29* (50)	.04 (50)	-.02 (50)
Im-Re	-	-	-	-	-	-	-	-	-	.84***	.40***	-.12 (50)	-.19 (50)	.10 (50)
De-Re	-	-	-	-	-	-	-	-	-	-	.48***	-.08 (50)	-.24 (50)	.07 (50)

To see the overall picture, results were collapsed across GSS1 and GSS2, FA(oddball) showed a positive correlation with DRM-FA., $r=.30$, $p<01$. DRM-FA showed positive correlations with Yield1 ($r=.30$, $p<.01$), Yield2 ($r=.26$, $p<.05$), and TS ($r=.27$, $p<.05$), but had negative correlations with NEW ($r= -.53$, $p<.001$), Immediate Recall ($r= -.31$, $p<.01$), Delayed Recall ($r= -.28$, $p<.01$), and Recall word ($r= -.38$, $p<.001$). These mean that participants who had high false alarm especially in DRM paradigm were more likely to yield to the leading questions, and tended to have a less memory capacity. In addition, immediate recall and delayed recall of GSS had positive correlations with Recall word from DRM ($r=.40$, $p<.001$ and $r=.48$, $p<.001$, respectively). This indicates that both free recall paradigms have some overlapped constructs (GSS measures story recall, whereas DRM measures word recall). In addition, IS measures were not significantly correlated with GCS data. This is consistent with Gudjonsson's (2003) report that Interrogative Suggestibility is poorly correlated with compliance. For the overall results, Misleading questions from the PEMQ had positive correlations with Yield1 ($r=.24$, $p<.09$), Yield2 ($r=.26$, $p<.08$), Shift ($r=.33$, $p<.05$), and TS ($r=.29$, $p<.05$). This is consistent with Eisen et al. (2002)'s hypothesis that misleading questions are analogous to Yield1 scores (albeit marginally significant).

In conclusion, GSS1 data correlated more (significantly) with PEMQ data. In contrast, GSS2 data correlated more with DRM data.

Behavioural differences in the oddball task between each group of variables are shown as follows.

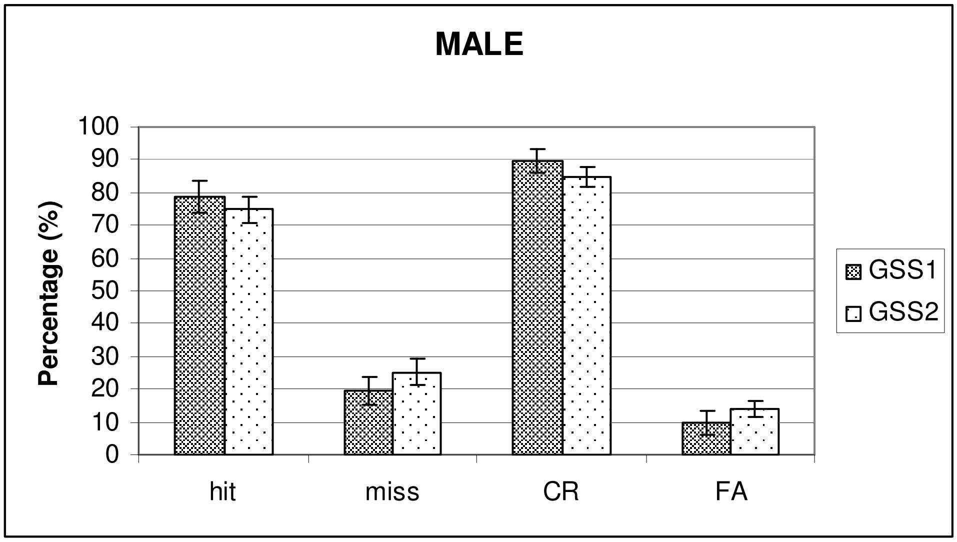
Oddball performance (reaction time and accuracy)

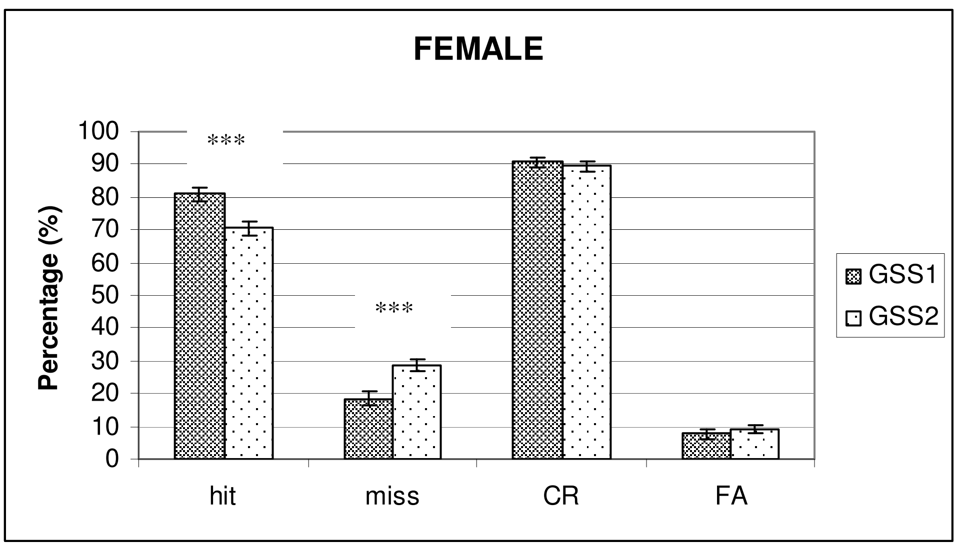
Between males and females vs. between GSS1 and GSS2

After screening for outliers (z= +/-2.58), a [2 Condition (hit, CR) x 2 SEX x 2 GSS] ANOVA was performed (71 females, 18 males, 40 GSS1 participants, 49 GSS2 participants). There was a main effect of Condition, $F(1,85)=27.42$, $p<.001$, but no other significant interactions. However, the analysis of oddball performance was analyzed separately for males and females due to a small number of male participants which were excluded from the ERP analysis. In addition, males and females seem to show different ERPs patterns (whose difference has to be explored in future research). The analysis of oddball performance confined only female participants found a main effect of Condition, $F(1,69)=53.79$, $p<.001$ and an (Condition x GSS) interaction, $F(1,69)=6.02$, $p<.05$. This interaction indicates that oddball performance was different between GSS1 and GSS2. Therefore, independent t-tests were performed to compare GSS1 and GSS2 on reaction time and percentage of correction and error for Old (relevant, Condition 2; C2) and New (irrelevant, Condition 3; C3) conditions.

Oddball performance data and reaction time compared between GSS1 and GSS2 separately for males and females are shown in Figure 5 and Figure 6, respectively. In addition, post hoc analyses using independent t-tests were performed and significance level were shown with asterisks (*) on the figures.

Figure 5 Oddball performance data (accuracy) compared GSS1 and GSS2, separately for males and females (hit=old/old, miss=old/new, CR=new/new, FA=new/old), ***p<.001

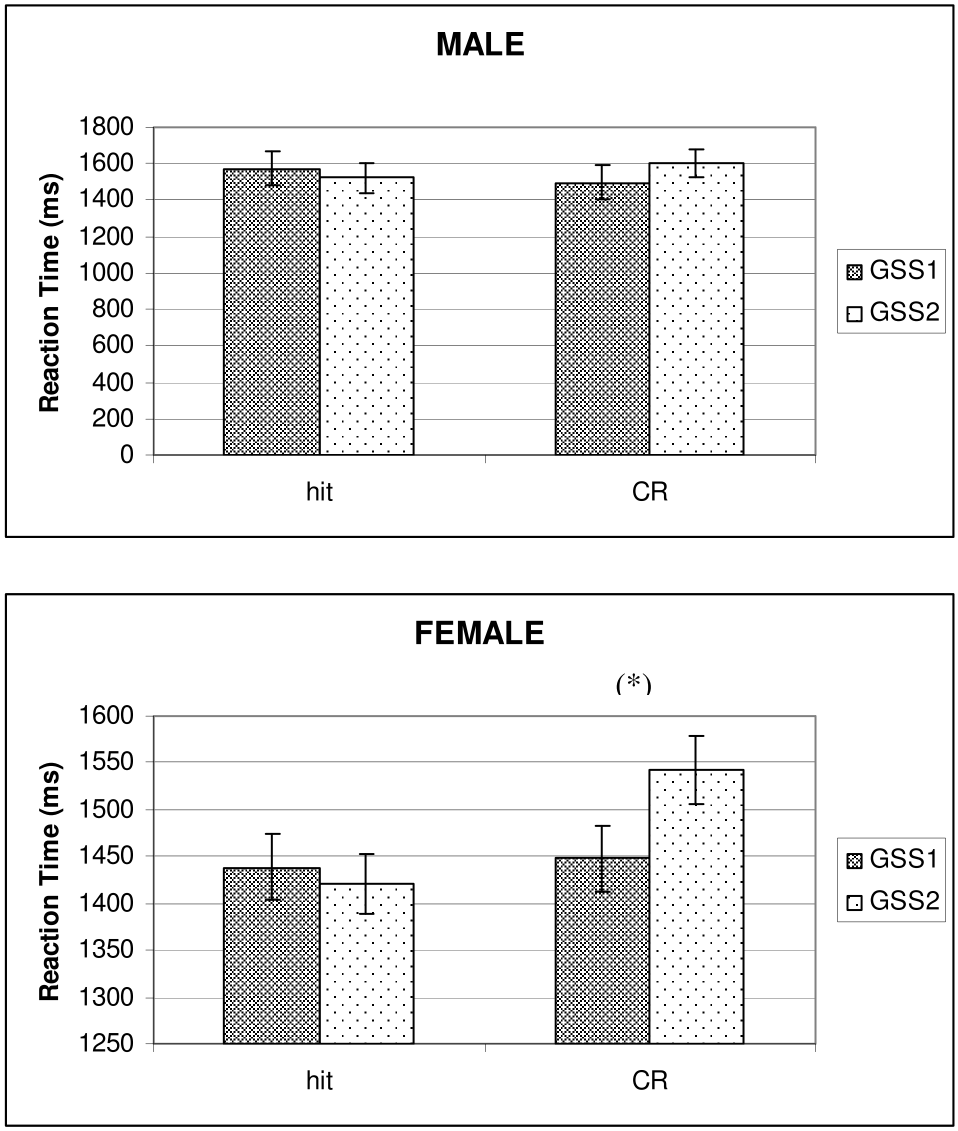




From Figure 5, for female participant, there were significant differences for Hits, t(70)=3.65, p<.001 and for Miss, t(70)= -3.59, p<.001. GSS1 had more Hits than GSS2 and GSS2 had more Misses than GSS1. This means that female participants pressed the buttons more accurately for the Old condition of GSS1 than that of GSS2. This may be because the content and pictures from the GSS1 story are more obvious than those of

GSS2. For male participants, there were no significant differences. This may be due to a small number of male participants.

Figure 6 Reaction Times (in milliseconds; ms) of C2 (hit) and C3 (CR) compared between GSS1 and GSS2, separately for males and females



There were no significant differences of reaction time for GSS1 and GSS2. There was only a marginally significant difference of reaction time of the new condition for females, RT (CR), $t(69)= -1.85$, $p<.07$.

Oddball task performance (accuracy and reaction time) for females whose brain waves were used for ERP analysis (N=65) also yielded the similar results as Figures 5 and 6 (For accuracy, a main effect of Condition, $F(1,61)=52$, $p<.001$; a (Condition x GSS) interaction, $F(1,61)=8.4$, $p<.01$; For reaction time, a main effect of Condition, $F(1,62)=11.4$, $p<.01$; a (Condition x GSS) interaction, $F(1,62)=6.55$, $p<.05$). For independent t-tests of hits, $t(63)=4.01$, $p<.001$, of CR reaction time, $t(62)= -1.93$, $p<.06$.

However, oddball task performance compared between males and females of either GSS1 or GSS2 were not significantly different (albeit marginally different for false alarms of GSS2, see Table 12).

Oddball task performance:

<u>Between TS measures</u>

For oddball behavioural data (hits, misses, correct rejections, false alarms, and all reaction times), there were no significant differences of either GSS1 or GSS2 between low and high Yield1, Yield2, Shift, and TS individuals.

<u>Between memory measures</u>

<u>Immediate recall</u>

For GSS1, high Immediate Recall individuals had more correct rejections and lower false alarms than low Immediate Recall, $t(24)= -2.05$, $p<.06$; $t(24)=2.24$, $p<.05$, respectively. This indicates that higher recall individuals tend to classify the pictures more accurately. In other words, poor memory performers also performed more poorly in the oddball task. For GSS2, there were no significant differences of behavioural data between low and high Immediate Recall individuals.

Delayed recall

There were no significant differences of behavioural data between low and high Delayed Recall individuals of either GSS1 or GSS2.

DRM free recall (Recall Word)

For GSS1, high Recall word individuals had more correct rejections and lower false alarms than low Recall word individuals, $t(24)= -3.37$, $p<.01$; $t(24)=3.78$, $p<.01$, respectively. For GSS2, high Recall word individuals had more hits and fewer misses than low Recall word individuals, $t(26)= -3.09$, $p<.01$; $t(26)=2.54$, $p<.02$, respectively. In addition, high Recall word individuals had longer reaction time for hits and longer reaction time for correct rejections than low Recall word individuals, $t(26)= -3.12$, $p<.01$; $t(26)= -2.10$, $p<.05$, respectively. This again indicates that individuals who have high memory recall tend to classify pictures more accurately and take more time to decide whether the pictures are relevant or irrelevant to the story.

Recognition (old classified as old in DRM)

For GSS1, high Recognition individuals had longer reaction time for misses than low Recognition individuals, $t(24)=2.25$, $p<.05$. For GSS2, high Recognition individuals had longer reaction time for hits and correct rejection than low Recognition individuals, $t(24)= -2.37$, $p<.05$; $t(24)= -1.99$, $p<.06$, respectively. This indicates that individuals who have more recognition capacity tend to take more time to classify the pictures.

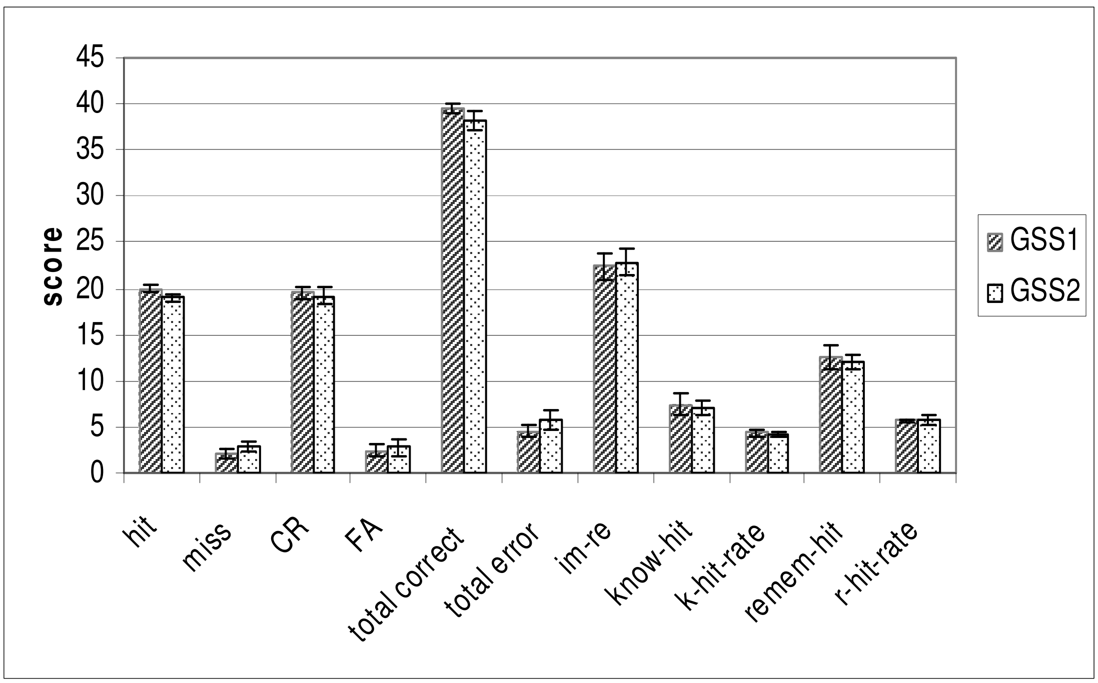
<u>DRM-FA</u>

For GSS1, low DRM-FA individuals had more correct rejections and fewer oddball false alarms than high DRM-FA individuals, $t(18.19)=2.13$, $p<.05$; $t(18.22)=-2.37$, $p<.05$, respectively. This indicates that DRM-FA is consistent with FA (oddball). For GSS2, there were no significant differences.

Another small study was conducted in New Zealand by my supervisor (Assoc. Prof. Dr. Richard Howard) and me during the time I visited my supervisor in New Zealand to confirm the differences between GSS1 and GSS2. It was a post-hoc comparison of the GSS1 and GSS2 pictures, to verify that they were equivalent in terms of memory performance. Participants listened to either GSS1 or GSS2, then participants saw the drawing pictures one by one depicted the scenes of GSS1 and GSS2 (the same pictures as C2 and C3 used in ERP measurement). Immediately after each picture, participants circled OLD (already heard from the story) or NEW (never heard from the story) in the questionnaire. If they circled OLD, they had to classify it as KNOW or REMEMBER, including rating the degrees of KNOW or REMEMBER from 1 to 7 (see Appendix H for the examples of the questionnaire).

Altogether, there were 24 participants, 12 participants in GSS1 (two males) and 12 participants in GSS2 (three males). The results are shown in Figure 7.

Figure 7 Participants' rating of picture recognition compared between GSS1 and GSS2 (conducted in New Zealand), CR= Correct Rejection (New press New), FA= False Alarm, im-re= immediate recall, know-hit=correct recognition (Old press Old) and pictures identified as know, k-hit-rate=participants rated the degree (1 to 7) for how much they knew pictures after correct recognition, remember-hit=correct recognition and pictures identified as remember, r-hit-rate= participants rated the degree (1 to 7) for how much they remembered pictures after correct recognition.



From Figure 7, it may be seen that there were no significant differences between GSS1 and GSS2 for all of the variables. This may be due to a small number of participants. However, GSS1 seemed to have more hits and correct rejections, less errors (misses and false alarms), but less immediate recall than GSS2. This may be due to GSS1 pictures (robbery) were more striking than GSS2 pictures, but the GSS1 story had more details than the GSS2 story. Participants could not recall the GSS1 story verbally as well as the GSS2 story, but they could recognize GSS1 pictures more than GSS2 pictures. The evidence that participants tended to claim that they knew or remembered more GSS1 pictures than GSS2 pictures (see Figure 7) supports this assumption. These results (albeit no significant differences due to a small number of participants) are consistent with the present study that participants made more hits (less misses) in GSS1 than in GSS2 (see Figure 5 for females).

Summary of Results and Discussion

The aim of the study in this chapter is to answer the research questions as follows: *1. Do GSS1 and GSS2 give equivalent results on the various measures of recall and IS? Are they comparable to the norms presented by Gudjonsson (1997)?*

GSS1 showed higher Yield1 than GSS2, whereas GSS2 showed higher immediate and delayed recall than GSS1. This shows that participants could remember the details of GSS2 more than those of GSS1; therefore, they tended to yield to the leading questions of GSS1 because they could not remember the details of GSS1 as much as those of GSS2. This may be because GSS1 had more details than GSS2. However, for the oddball task, participants made less error of button press for GSS1 pictures than for GSS2 pictures. This may be because GSS1 pictures were more striking than GSS2 pictures (GSS1 is the robbery story whereas GSS2 is the spoiled brake story). In addition, the correlations of PEMQ measures and GSS measures were more prominent in GSS1, whereas the correlations of DRM-FA and GSS measures were more prominent in GSS2.

Comparing the results from Table 12 with Gudjonsson's norms in Appendix I, GSS1 results from the present study showed similar ranges and means to those of Gudjonsson's. However, GSS2 participants in the present study showed higher immediate and delayed recall than those of Gudjonsson's and had lower Yield1 scores than Gudjonsson's. This indicates that participants in the present study were able to remember the GSS2 story details better than Gudjonsson's participants.

In addition, GCS has weak correlations with GSS variables (immediate recall, delayed recall, Yield, Shift, and TS), when compared to the correlations from Gudjonsson (1997, not shown here). This may be due to different groups of participants. Gudjonsson (1997) used forensic cases, whereas the present studies used students. However, Gudjonsson (2003) also says that the GCS and GSS suggestibility measures are poorly correlated.

2. Do male and female participants give equivalent results on the various measures of recall and IS?

From Table 12, males and females give equivalent results for almost overall results. However, females had more immediate and delayed recall than males in GSS2. These results are not consistent with Gudjonsson (1997)'s results in which he found no significant differences in IS for men and women in his norm of general population. However, the result of GSS2 of the present study is consistent with previous studies (e.g. Lowe, Mayfield, and Reynolds, 2003) that females outperform males in verbal memory tasks, and males outperform females in spatial tasks.

3. What are the relationships between measures of IS – i.e., Yield1, Yield2, Shift, and TS (GSS1 and GSS2) and the yield measure from the PEMQ?

In this study, for overall results (see Table 15), there were the correlations between the PEMQ measures (only misleading questions, not repeated questions) and IS measures (GSS1 and GSS2). However, the correlations of the misleading questions of the

PEMQ and TS seemed to be clearly seen in GSS1 than in GSS2 (see Table 13 for GSS1 and Table 14 for GSS2).

4. What are the relationships between the various measures of Memory – i.e., Free recall (DRM, GSS immediate recall and delayed recall) and false alarm (oddball and DRM)?

DRM-FA tended to have negative correlations with immediate recall, delayed recall, and Recall word (DRM-free recall) for both GSS1 and GSS2. FA (oddball) tended to have negative correlations with immediate recall, delayed recall, and Recall word especially for GSS1 (see Tables 13 and 14). These correlations indicate that the memory capacity for recall appears to play a crucial role for individual differences in the tendency to make false alarms to lure. As expected, the correlations between DRM-free recall and GSS-free recall (immediate and delayed recalls) were more positive than those of DRM-recognition (old, new) and GSS-free recall. Moreover, FA (oddball) negatively correlated with the memory measures (immediate recall and DRM-free recall), but only in GSS1. This means that the oddball task was tapping into memory capacity in GSS1.

5. What are the relationships between memory measures and IS measures?

Memory measures and IS measures were highly negatively correlated (see Table 13, 14, 15). This means that participants who have lower memory capacity, tend to yield more to the leading questions. However, Shift and memory measures were not highly correlated. This indicates that memory capacity plays an important role in Yield, but not Shift of IS. In addition DRM-FA had positive correlations with TS. This indicates that people who made more false alarms (especially DRM-FA) tended to be more suggestible.

However, the correlations between GSS memory recall and IS were more negatively correlated than the correlations between DRM-free recall and IS. Therefore, that event memory in one setting may not be a good predictor of suggestibility in a second setting (Bruck & Melnyk, 2004) might be possible, when self-report questionnaires are used. They suggested "previous findings that good memory for the details of an event is associated with low levels of suggestibility (e.g. Marche, 1999; Marche & Howe, 1995; Pezdek & Roe, 1995) reflect context-specific factors rather than cognitive profiles of individual children (p.987-988)". Future research needs to clarify this.

Next will be the results of an examination of the relationship between personality variables and IS.

Chapter 4

Result 2: Personality Correlates of Interrogative Suggestibility (IS)

This chapter reports results using correlations (Pearson's r) to explore relationships between the Big Five personality factors (Goldberg, 1990; Extraversion, Agreeableness, Conscientiousness, Emotional Stability and Intellectuality), memory (DRM measures, PEMQ measures and GSS measures), GCS, and GSS measures of IS. It was predicted that personality variables (compliance as measured by GCS, Big Five factor scores) would be significantly intercorrelated, but that they would show small, if any, correlations with measures of IS. The latter, as indicated in Chapter 1 (see Figure 1), represent responses to a suggestive stimulus, and, being influenced by contextual variables such as interpersonal trust, uncertainty and expectations, are much more *context-driven* than are the stable and enduring traits reflected in measures of personality.

Results and Discussion

Pearson correlations between five factor personality variables and the variables of interest are shown in Table 16 (data are collapsed across GSS1 and GSS2, and across males and females) and Tables 17 and 18 for separate GSS1 and GSS2.

Table 16 Pearson correlations between five factor personality variables and the variables of interest of collapsed GSS1 and GSS2 (N=90, unless specified in parentheses)

Variable	Agreeableness	Conscientiousness	Emotion stability	Intellectual	FA oddball	GCS	Old	New	DRM-FA	Recall word (DRM)	Im-recall	De-recall	Yield1	Yield2	Shift	TS	Mis-Lead-Ing# PEMQ	Speci-fic#	Re-Peat#
Extraversion	.06 (88)	-.001	.32**	.21*	-.11 (89)	-.44***	-.03	-.19 (85)	.15	.04	-.19(*)	-.16	.17	.04	-.06	.06	-.02 (45)	-.04 (45)	.01 (45)
Agreeableness	-	.38** (88)	.24** (88)	.32** (88)	-.01 (88)	.01 (88)	.16 (88)	-.11 (83)	-.03 (88)	-.08 (88)	.03 (88)	.03 (88)	-.15 (88)	-.22* (88)	-.14 (88)	-.17 (88)	.02 (45)	-.09 (44)	.11 (44)
Conscientiousness	-	-	.30**	.11	-.04 (89)	-.02	.01	-.01 (85)	-.04	.03	.06	.14	.08	.03	.06	.07	.16 (45)	.08 (45)	.12 (45)
Emotion stability	-	-	-	.25*	-.18 (89)	-.24**	-.08	.06 (85)	-.05	.26*	.12	.18(*)	.12	-.03	-.03	.03	-.06 (45)	.14 (45)	-.16 (45)
Intellectual	-	-	-	-	.003 (89)	-.10	.05	-.22* (85)	.13	-.04	-.11	-.08	.00	-.06	-.14	-.10	.15 (45)	-.12 (45)	.14 (45)

(*)p<.01, *p<.05, **p<.01, ***p<.001
#the PEMQ paradigm, numbers of participants were applied only in Study 1 (no PEMQ paradigm for Study 2)

Table 17 Pearson correlations between five factor personality variables and the variables of interest of GSS1 (N=42, unless specified in parentheses)

Variable	Agree ableness	Con scien tious ness	Emo tion stabi-lity	Intellec tual	FA oddball	GCS	Old	New	DRM FA	Recall word (DRM)	Im-recall	De-recall	Yield1	Yield2	Shift	TS	Mis-Lead-Ing# PEMQ	Speci-fic#	Re-Peat#
Extraver-sion	.08 (41)	.28(*)	.28(*)	.19	-.07 (41)	-.32*	-.20	-.23 (39)	-.04	.07	-.06	-.08	-.14	-.01	.003	-.08	.22 (23)	-.07 (23)	.33 (23)
Agree-ableness	-	.35* (41)	.14 (41)	.47** (41)	-.05 (41)	.03 (41)	.26 (41)	-.16 (38)	-.12 (41)	-.24 (41)	-.21 (41)	-.06 (41)	.01 (41)	-.20 (41)	-.16 (41)	-.09 (41)	.11 (23)	-.05 (23)	.24 (23)
Conscien tiousness	-	-	.40**	.09	.08 (41)	-.34*	-.10	.11 (39)	-.22	-.003	-.19	.03	.19	.06	.06	.18	.19 (23)	.09 (23)	.29 (23)
Emotion stability	-	-	-	.35*	.10 (41)	-.24	-.11	.10 (39)	-.10	.30(*)	.02	.18	.05	-.17	-.05	-.01	.01 (23)	.25 (23)	.17 (23)
Intellec-tual	-	-	-	-	-.17 (41)	-.07	-.11	-.15 (39)	-.02	-.21	-.23	-.13	.06	-.10	-.26	-.13	-.01 (23)	-.42* (23)	.27 (23)

(*)p<.01, *p<.05, **p<.01, ***p<.001
#the PEMQ paradigm, numbers of participants were applied only in Study 1 (no PEMQ paradigm for Study 2)

Table 18 Pearson correlations between five factor personality variables and the variables of interest of GSS2 (N=48, unless specified in parentheses)

Variable	Agreeableness	Conscientiousness	Emotion stability	Intellectual	FA oddball	GCS	Old	New	DRM-FA	Recall word (DRM)	Im-recall	De-recall	Yield1	Yield2	Shift	TS	Mis-Lead-Ing# PEMQ	Specific#	Re-Peat#
Extraversion	.08 (47)	-.19	.37*	.25(*)	-.08 (48)	-.51**	.17	-.26(*) (46)	.26(*)	.01	-.16	-.12	.29*	.06	-.08	.10	-.34 (22)	-.13 (22)	-.16 (22)
Agreeableness	-	.40** (47)	.33* (47)	.14 (47)	-.01 (47)	-.03 (47)	.02 (47)	-.03 (45)	.05 (47)	.08 (47)	.19 (47)	.09 (47)	-.28(*) (47)	-.26(*) (47)	-.14 (88)	-.17 (88)	-.16 (22)	-.18 (21)	-.07 (21)
Conscientiousness	-	-	.22	.13	-.17	.23	.09	-.03 (46)	.12	.07	.18	.17	.07	.01	-.02	-.01	.16 (22)	.12 (22)	-.11 (22)
Emotion stability	-	-	-	.17	-.32*	-.26(*)	-.08	.06 (46)	-.02	.24(*)	.16	.18	.21	.05	-.03	.06	-.18 (22)	.01 (22)	-.45* (22)
Intellectual	-	-	-	-	.11	-.12	.22	.28(*) (46)	.25(*)	.11	-.06	-.06	-.04	-.04	-.05	-.08	.32 (22)	.14 (22)	.04 (22)

(*)p<.01, *p<.05, **p<.01, ***p<.001
#the PEMQ paradigm, numbers of participants were applied only in Study 1 (no PEMQ paradigm for Study 2)

It may be seen from Table 16 that GCS correlated negatively with extraversion and emotional stability. This means that participants who were introverted and emotionally unstable tended to be compliant. This is consistent with Shatz's (2004) finding that the compliance scale from Horney's three neurotic types (Coolidge, Moor, Yamazaki, Stewart, &, Segal, 2001) and neuroticism from Eysenck's (Eysenck, S.B.G., Eysenck, H.J., & Barrett, 1985) Personality Questionnaire-Revised (EPQ-R) loaded onto the same factor. Gudjonsson (1989) also found a significant positive correlation ($r=.27$, $p<.05$) between compliance measured by the GCS and Neuroticism measured on the Eysenck Personality Questionnaire (EPQ; Eysenck & Eysenck, 1975). A relationship between compliance and negative affectivity therefore appears to be a reliable finding, but these results suggest that compliance reflects the interaction of extraversion and neuroticism, with compliant individuals being neurotic introverts, and non-compliant individuals being stable extroverts.

It may additionally be seen from Table 16 that DRM-free recall correlated positively and significantly with emotional stability. In addition, this correlation showed in both GSS1 and GSS2 (see Tables 17 and 18, albeit marginally significant due to smaller numbers of participants) and GSS delayed recall tended to correlate with emotional stability, $r=.18$, $p<.1$). This indicates that participants who were emotional stable were better able to recall words especially as measured by DRM free recall. This is an unexpected and interesting finding, suggesting that the ability to recall verbal material is associated with emotional stability. However, given that DRM Free Recall correlated only modestly (albeit significantly) with emotional stability, too great importance should not be attached to this finding. As predicted, however, there were no significant correlations between GSS suggestibility measures and personality variables. Haraldson (1985) also found no significant correlation between GSS1 suggestibility scores and neuroticism as measured by the Icelandic version of the Eysenck Personality Questionnaire (EPQ; Eysenck & Haraldsson, 1983). For overall results, there were no significant correlations between personality measures and PEMQ measures.

There were no significant correlations between GSS suggestibility measures and personality variables except Yield2 correlated modestly and negatively with agreeableness (see Table 16). This indicates that participants who were more agreeable tended to yield to the leading questions after negative feedback given.

Intercorrelations computed separately for participants who underwent either GSS1 or GSS2 also found a lack of significant correlations between Big Five personality variables and IS, with a single exception: for GSS2, there was a significant correlation between Yield1 and extraversion ($r=.29$, $p<.05$), while for GSS1, these variables did not correlate significantly ($r = -.14$). A *caveat* to this is that some relationships may exist between extraversion and Yield1 from GSS2. This finding further indicates that it should not be assumed that GSS1 and GSS2 are equivalent in terms of their correlates.

From Table 16 of collapsed GSS1 and GSS2, compliance of the GCS scale correlated negatively with extraversion and emotional stability. For GSS1, compliance of the GCS scale correlated negatively with conscientiousness. These indicate that neurotic introverts tend to be compliant or those who are compliant tend to be neurotic introvert. In addition, those who have low conscientiousness tend to be compliant or those who are compliant tend to have low conscientiousness, but this result showed only in GSS1.

It can be concluded that, as predicted, IS measures show a lack of relationship to personality variables, and a lack of correlations to compliance (see also Tables 13-15). However, compliance is higher in neurotic introverts than in stable extraverts.

Chapter 5

Result 3: ERP indices of memory in relation to individual differences in Interrogative Suggestibility (IS)

<u>Prologue:</u>

Results from the present study pertaining to ERP old/new effects, otherwise referred to as episodic memory (EM) effects, will be presented in relation to individual differences in IS, memory performance, and task performance. ERPs recordings were time-locked to old (related to the GSS story; Condition 2) and new (unrelated to the GSS story; Condition 3) events. The central question, as outlined previously, is: *Do ERP correlates of memory confirm a relationship between individual differences in IS and differences in neurocognitive processing as related to memory?*

<u>Hypothesis of memory and ERPs results</u>

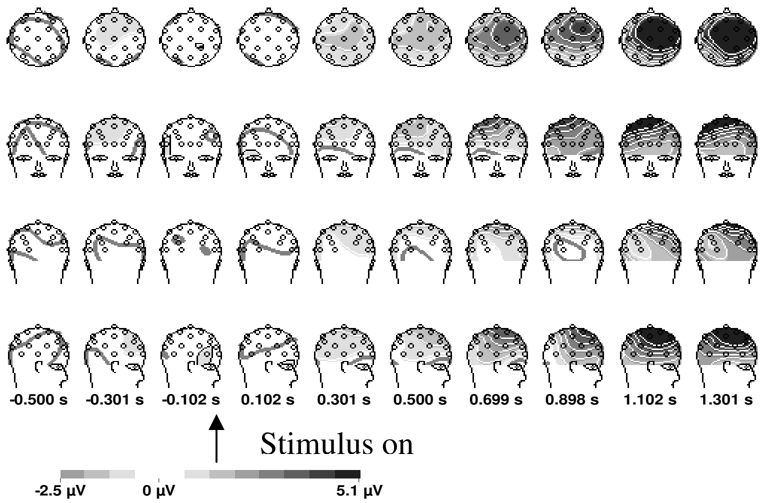
As stated in Chapter 1, suggestible individuals were predicted to show a lack of at least one of the ERP old/new effects that are components of memory (familiarity, recollection, and post retrieval evaluation), when compared to non-suggestible individuals. In addition, poor performers (in free recall, oddball) were predicted to show lacks of the ERP old/new effects, when compared to good performers.

<u>Results: ERP old/new Effects, Memory and IS</u>

Grand averages and topographical maps at successive 200 ms intervals were generated using all 32 electrodes. First of all, topographical maps and ERP old/new effects were generated across all participants, then females and males separately, and GSS1 and GSS2 separately, finally each low and high groups of Total Suggestibility (TS) and related variables. The significant old/new effects that were shown (with asterisks) in all Figures using paired t-tests between old and new conditions.

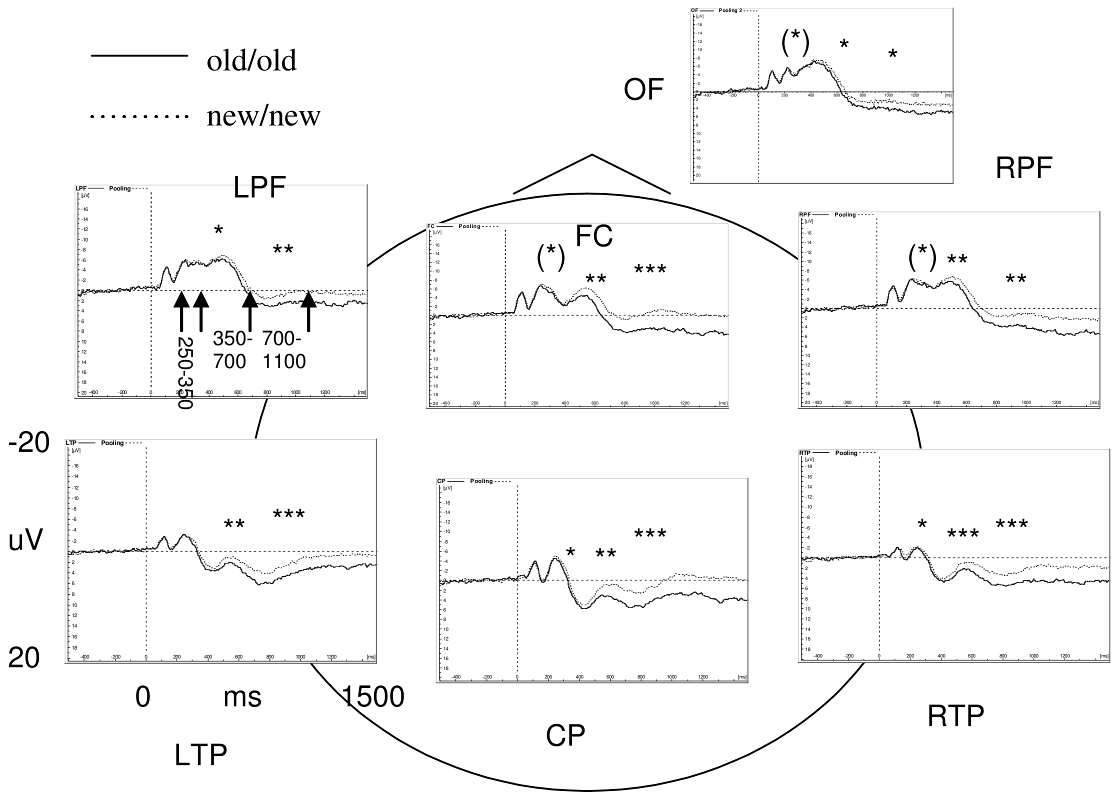
Topographical maps and ERP old/new effects showing ERP old-new differences for overall participants (GSS1 and GSS2, males and females, N=84) are shown in Figure 8 (a and b).

Figure 8a Topographical maps (old-new) of overall participants (N=84). Darker shaded areas indicate greater old/new differences.



From Figure 8a, the differences of (old-new) were seen around 250-300 ms post stimulus onwards and tended to increase over time post-stimulus, being maximal around 700-1100 ms post stimulus. The old/new difference was visible anteriorly at 300 ms, had a frontocentral focus around 900 ms, and then intensified and spreaded laterally to temporal and prefrontal areas particularly at the right hemisphere.

Figure 8b Old/new effects at each region of interest, with significant old/new effects shown (N=84), (*)p<.1, *p<.05, **p<.01, ***p<.001, old/old=solid line, new/new=dotted line

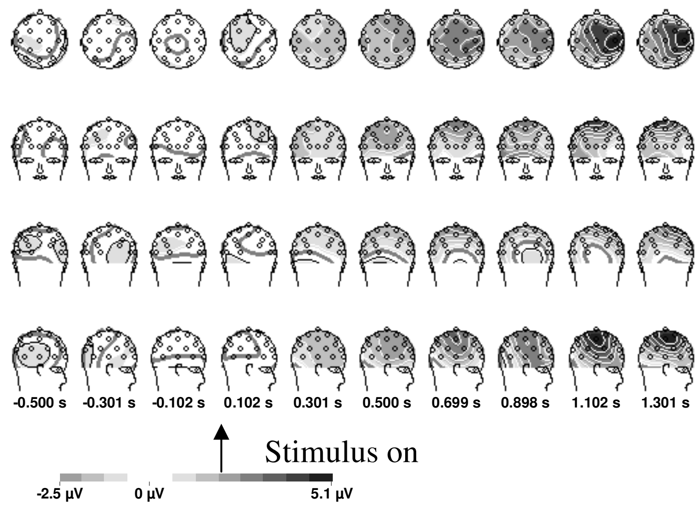


Significant old/new effects (using paired t-tests) with more positive going voltages in "old" than "new" conditions were seen at most scalp regions and intervals, but most prominent and reliably at frontocentral, centroparietal, and right temporoparietal locations, particularly during the late (700-1100) interval.

Scalp topography and ERPs were analyzed separately for (a) females and males (GSS1 and GSS2 combined) whose results are shown in Figure 9a and b (b) GSS1 and GSS2 (males and females combined) whose results are shown in Figure 10a and b.

Figure 9a Scalp topography compared females (N=65) and males (N=19). Darker shaded areas indicate greater old/new differences. Darker shaded areas indicate greater old/new differences.

FEMALE



MALE

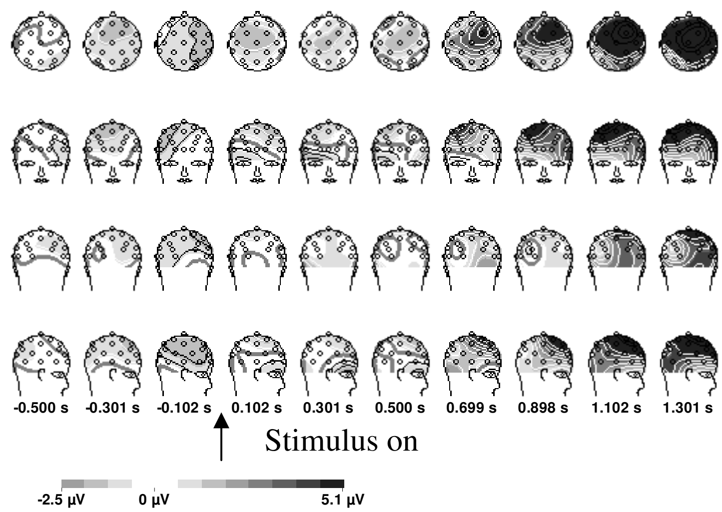
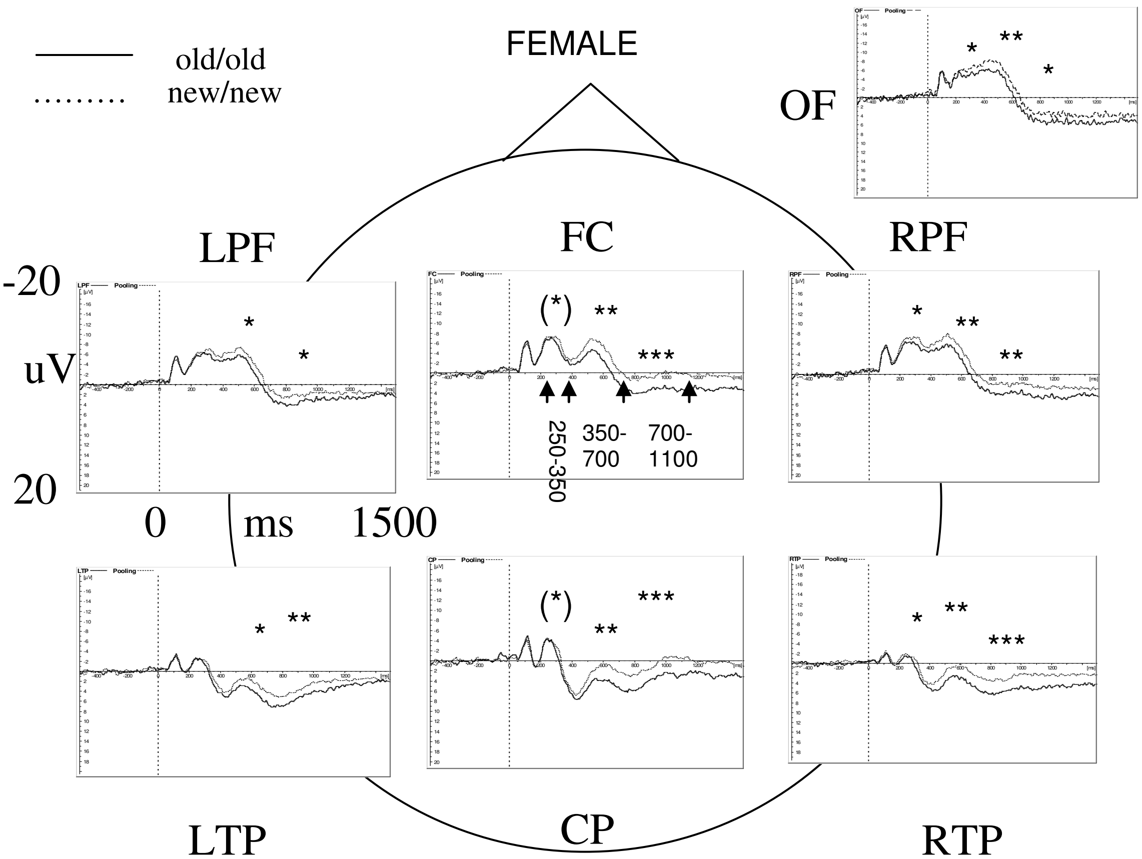
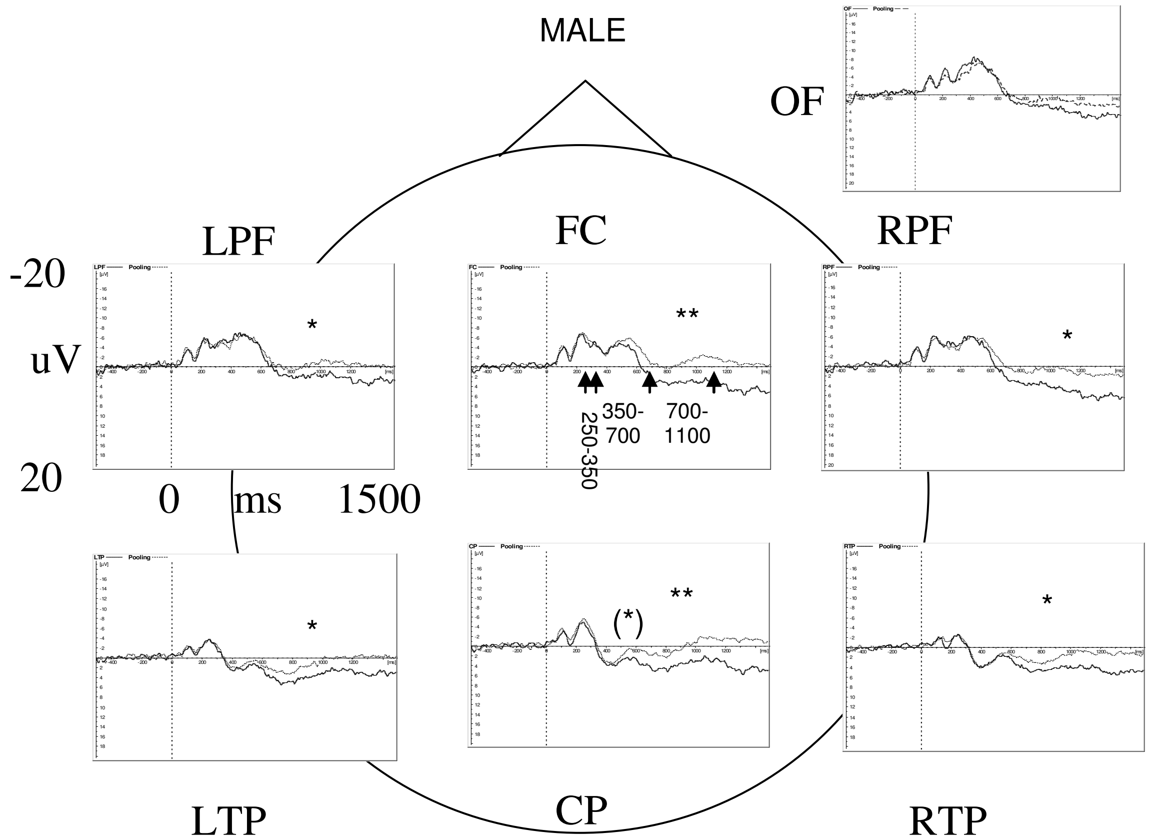


Figure 9b Old/new grand averages at each region of interest, with significant old vs. new differences shown compared between females (N=65) and males (N=19), (*)p<.1, *p<.05,**p<.01, ***p<.001, old/old=solid line, new/new=dotted line (GSS1 and GSS2 combined)

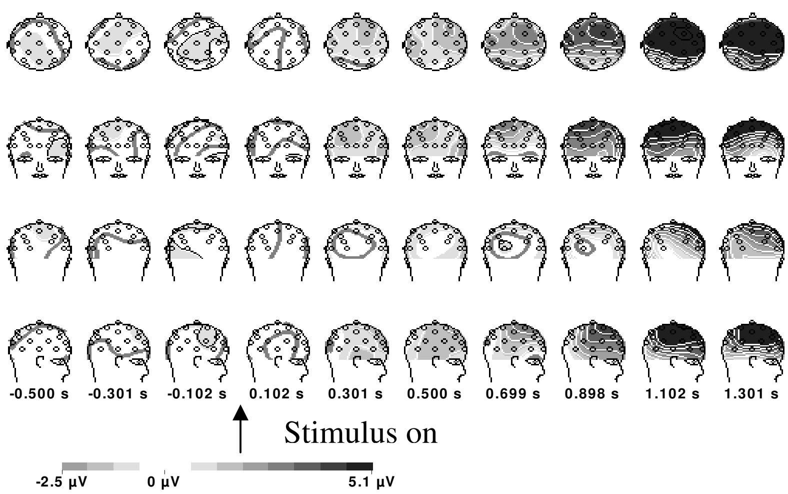




From Figure 9, males and females showed significant old/new effects at all regions of interest, especially at the 700-1100 ms interval; however, females showed stronger significant levels. It seems females show a more marked early old/new effect (300-700 ms post stimulus onset) than males, especially at OF and RPF. However, males seem to show a larger old/new effect after 700 ms post stimulus onset at FC and CP, albeit lower significantly different due to a smaller number of males.

Figure 10a Scalp topography compared GSS1 (N=37) and GSS2 (N=47), males and females combined. Darker shaded areas indicate greater old/new differences.

GSS1



GSS2

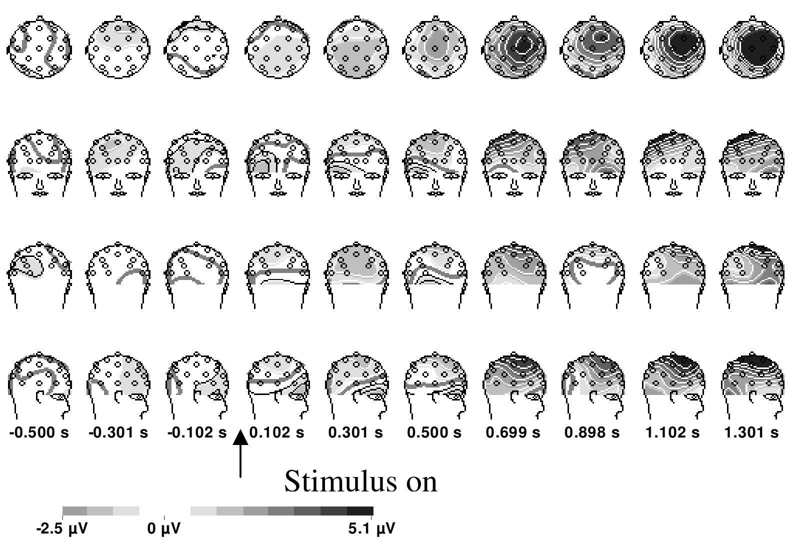
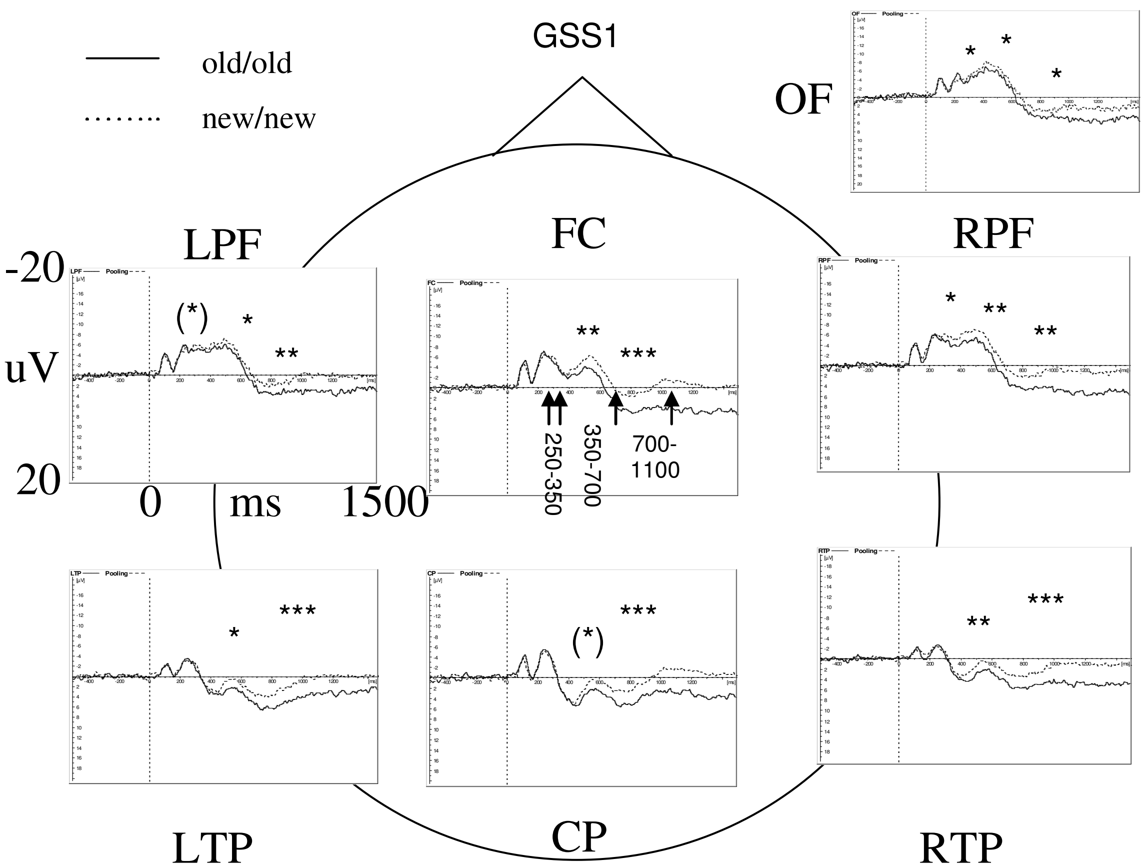
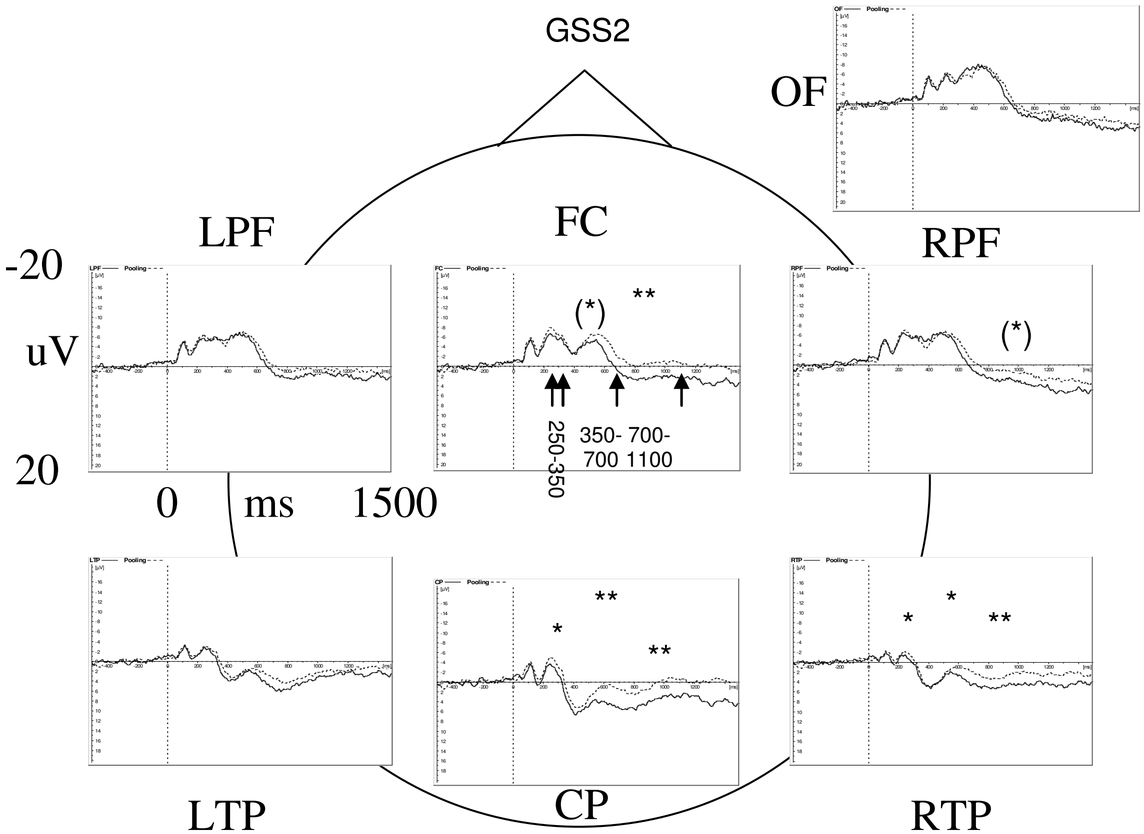


Figure 10b Old/new grand averages at each region of interest, with significant old vs. new differences shown compared between GSS1 (N=37) and GSS2 (N=47), (*)<.1, *p<.05, p**p<.01, ***p<.001, old/old=solid line, new/new=dotted line (males and females combined)





From Figure 10, GSS1 showed stronger significant old/new effects than GSS2.

In a preliminary phase, a four-factor repeated ANOVA (2 C x 7 region x 2 SEX x 2 GSS) on mean amplitudes of corresponding regions (LPF, OF, RPF, LTP, RTP, FC, and CP) at 250-350 ms, 350-700 ms and 700-1100 ms intervals were performed by using SEX and GSS as between-subject variables to see the effects of SEX (male, female) and GSS (GSS1, GSS2). The results are shown in Table 19.

Table 19 Summary of ANOVA results: 2 (conditions) x 7 (regions) x 2 (sex) x 2 (GSS)

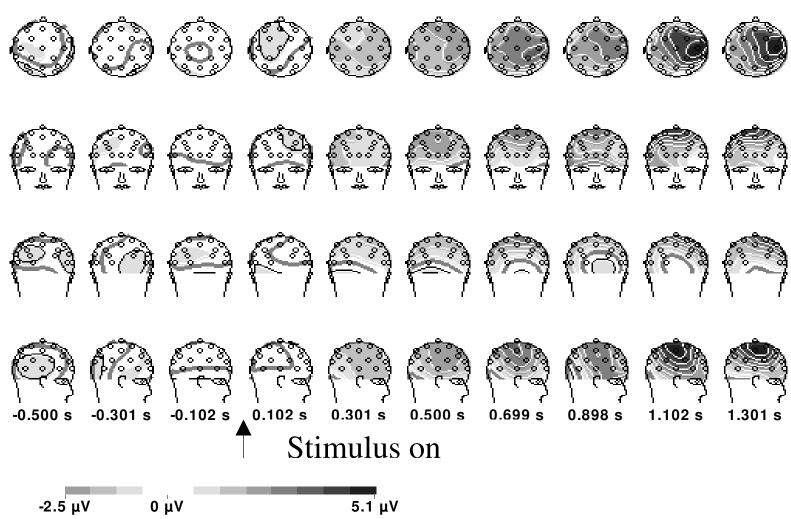
Source (df)	F-values		
	Early (250-350 ms)	Middle (350-700 ms)	Late (700-1100 ms)
SEX (1,80)	.33	.21	1.55
GSS (1,80)	.02	.04	.24
SEX x GSS (1,80)	1.27	2.31	1.36
C (1,80)	1.66	5.61*	19.90***
C x SEX (1,80)	.92	1.04	.16
C x GSS (1,80)	.04	.16	.69
C x SEX x GSS (1,80)	.73	.16	.84
Region (6,480)	34.57***	83.74***	4.28*
Region x SEX (6,480)	2.92*	.96	.78
Region x GSS (6,480)	.63	.67	.67
Region x SEX x GSS (6,480)	1.56	1.91	2.25(*)
Region x C (6,480)	.36	1.05	2.18(*)
Region x C x SEX (6,480)	1.03	.62	.36
Region x C x GSS (6,480)	1.88	1.06	.29
Region x C x SEX x GSS (5,400)	.45	.35	.22

***p < .001
** p < .01
* p < .05
(*) p < .1

Since at the 700-1100 ms interval, there were marginally significant interactions of (region x SEX x GSS) and (region x Condition), a separate (2 Condition x 2 SEX x 2 GSS) ANOVA for each region of interest was performed. There were marginally significant (SEX x GSS) interactions at LPF, OF and RPF, $F(1,80)=3.77$, $p<.06$; $F(1,80)=2.95$, $p<.10$ and $F(1,80)=3.06$, $p<.09$, respectively. There was a marginally significant main effect of SEX at OF, $F(1,80)=2.82$, $p<.10$. At the 250-350 ms interval, there was a significant (region x SEX) interaction. In addition, due to a small number of males and the oddball performance was more accurate in females than males, FA (oddball), $p<.1$ for GSS2 (see also Table 12, chapter 3); therefore, the following analyses were confined to female participants who underwent GSS1 and GSS2.

Topographical maps of female participants (N=65; GSS1, N=30 and GSS2, N=35) are shown in Figure 11 (GSS1 and GSS2 combined).

Figure 11 Topographical maps of females, GSS1 and GSS2 combined. Darker shaded areas indicate greater old/new differences.



ERP old/new effects were clearly seen around 250-300 ms onwards.

In a second phase of data analysis, three-factor repeated measure ANOVAs (7 region x 2 Condition x 2 GSS) for female participants at 250-350 ms, 350-700 ms and 700-1100 ms intervals were performed. The results are shown in Table 20.

Table 20 Summary of ANOVA results: 2 (conditions) x 7 (regions) x 2 (GSS)

Source (df)	F-values		
	Early (250-350 ms)	Middle (350-700 ms)	Late (700-1100 ms)
Region (6,378)	58.05***	101.52***	6.30**
Region x GSS (6,378)	0.79	0.64	0.71
Condition (1,63)	5.95*	13.76***	19.78***
Condition x GSS(1,63)	0.49	0.75	3.66(*)
Region x Condition(6,378)	0.48	0.48	1.83
Region x Condition x GSS (6,378)	3.17*	0.83	0.35
GSS (1,63)	1.16	2.03	0.58

*** p < .001, ** p < .01, * p < .05, (*) p < .1

There were significant main effects of Region and Condition at all intervals, but no Region x Condition interaction. There was a near-significant Condition x GSS interaction at the late interval, and a significant Region x Condition x GSS interaction at the early interval, indicating that the old/new effect was moderated by the version of GSS that participants underwent. When the old/new effect was examined separately for GSS1 and GSS2, it was much more prominent, and statistically reliable, for GSS1 than for GSS2 (see Figure 12, a and b).

Topographical maps of female participants separately for GSS1 and GSS2 (GSS1, N=30 and GSS2, N=35) are shown in Figure 12a and ERP old/new effects are shown in Figure 12b.

Figure 12a Scalp topography of separate GSS1 (N=30) and GSS2 (N=35). Darker shaded areas indicate greater old/new differences.

GSS1

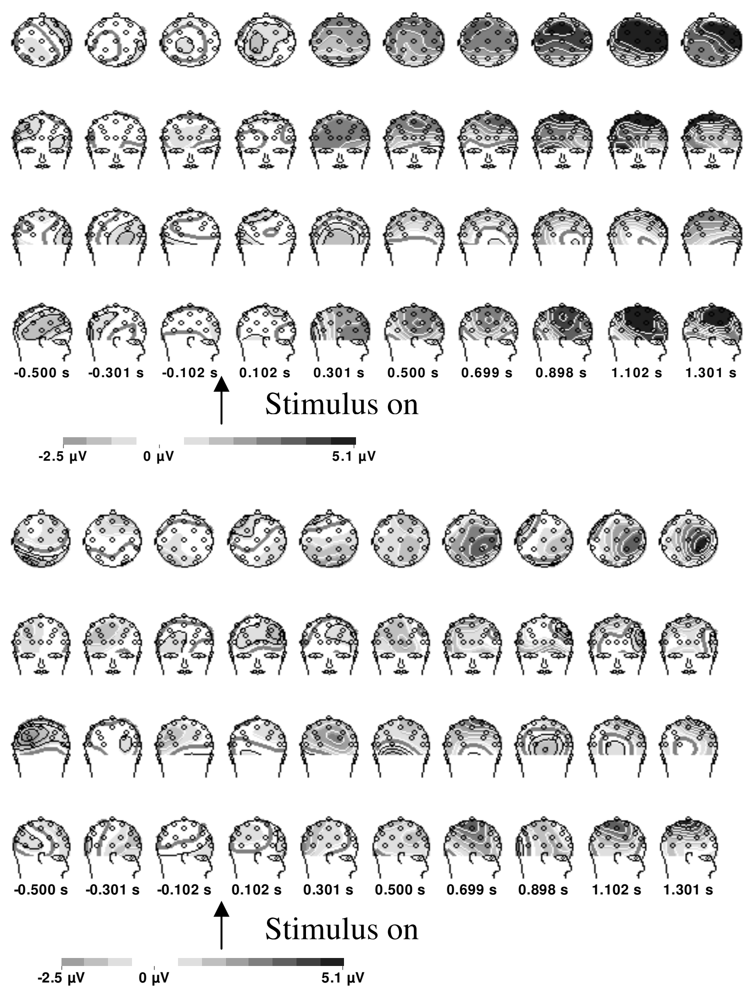
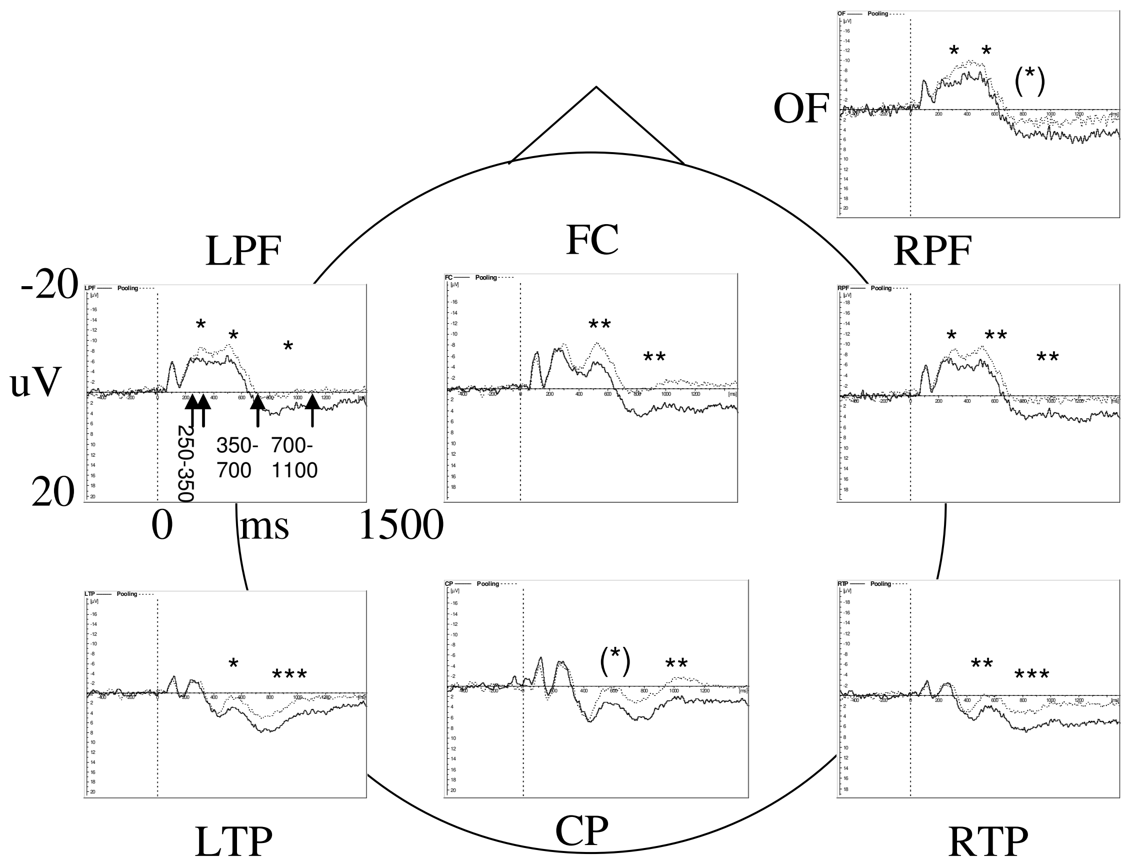
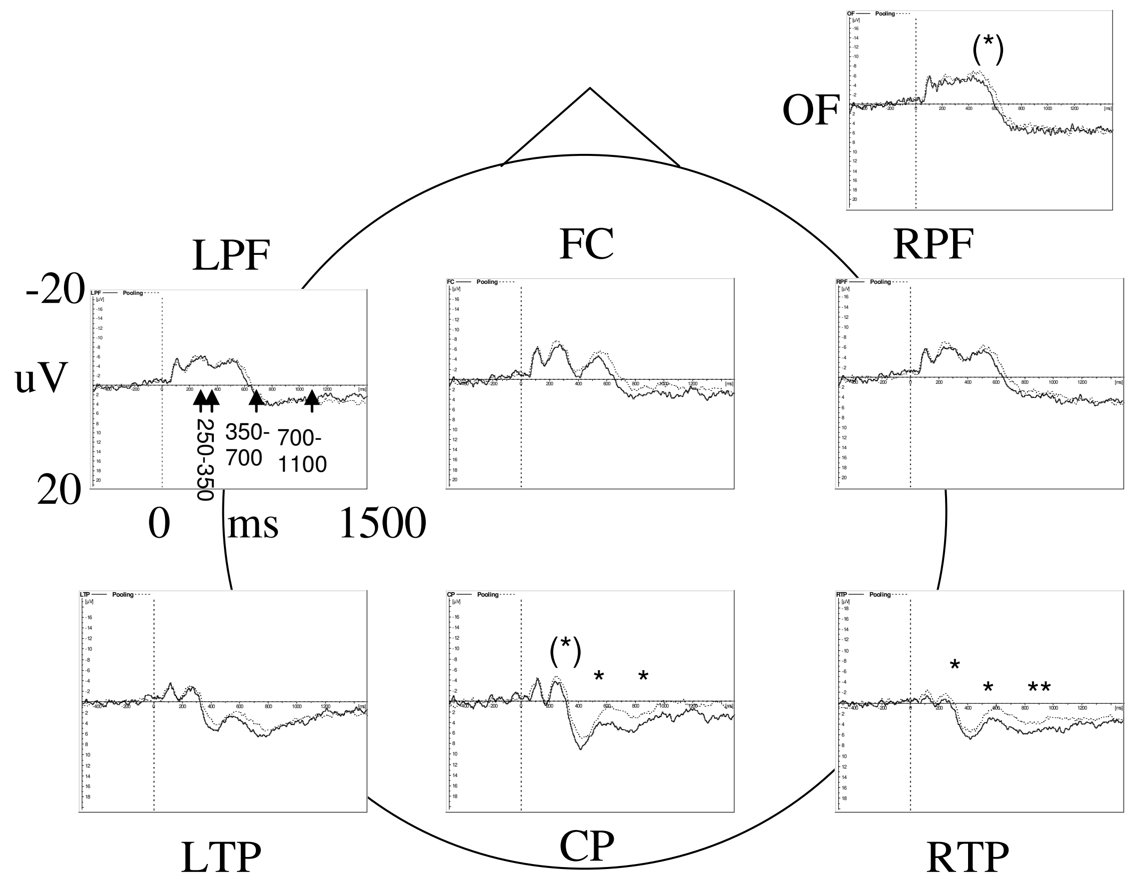


Figure 12b ERP old/new effects of female participants who underwent GSS1 and GSS2 (old/old=solid line, new/new=dotted line), (*)p<.1, *p<.05, **p<.01, ***p<.001.

GSS1



GSS2



From Figure 12a and 12b, ERP old/new effects were more clearly seen in GSS1 than in GSS2. In addition, oddball task performance, as shown in Figure 5 (chapter 3), was more accurate in participants undergoing GSS1 than in those undergoing GSS2

There were significant differences of REGION in all of the three intervals and there was a (region x C x GSS) at 250-350 ms; therefore, each region of interest was analyzed separately. First of all, (2C x 2GSS) ANOVAs were performed to see the overall results, and then, low and high groups of IS, memory performance and variables of interest were compared using three-factor repeated measure ANOVAs (2 C x 2 GSS x 2 group) for female participants at three intervals of interest. The results are shown in Table 21.

Table 21 Significance level of ANOVA results at each region of interest of three intervals of interest, ***p<.001, **p<.01, *p<.05, (*)p<.1

Variable (df)	Source	LPF			OF			RPF			LTP			FC			RTP			CP		
		250 - 350	350 - 700	700 - 1100	250 - 350	350 - 700	700 - 1100	250 - 350	350 - 700	700 - 1100	250 - 350	350 - 700	700 - 1100	250 - 350	350 - 700	700 - 1100	250 - 350	350 - 700	700 - 1100	250 - 350	350 - 700	700 - 1100
Overall (1,63)	C	-	*	*	*	**	*	*	**	**	-	*	**	(*)	**	***	*	***	***	-	**	***
	C x GSS	-	-	*	-	-	-	-	-	-	-	-	(*)	-	-	(*)	-	-	-	-	-	-
TS (1,48)	C x group	-	-	-	-	-	-	-	-	(*)	-	-	-	-	(*)	*	-	-	-	-	-	-
	C x GSS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yield1 (1,52)	C x group	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C x GSS	-	-	-	-	-	-	-	-	-	-	-	(*)	-	-	-	-	-	-	-	-	-
Shift (1,48)	C x group	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C x GSS	(*)	-	(*)	(*)	-	-	*	(*)	-	-	-	*	-	(*)	(*)	-	-	-	-	-	-
	C x GSS x group	-	-	-	-	-	-	*	(*)	(*)	-	-	-	-	-	-	-	-	-	-	-	-
Im-Re (1,48)	C x group	(*)	-	-	*	-	-	-	-	-	**	-	-	*	(*)	-	-	-	-	-	-	-
	C x GSS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C x GSS x group	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(*)	*	-
RW-DRM (1,50)	C x group	-	-	-	*	-	-	*	-	-	**	-	-	*	-	-	*	-	-	(*)	-	-
	C x GSS	(*)	(*)	(*)	(*)	-	-	*	*	-	-	*	**	-	-	(*)	-	-	-	-	-	-
FA-DRM (1,52)	C x group	(*)	-	-	(*)	-	-	-	-	-	-	-	-	(*)	-	-	-	-	-	-	-	-
	C x GSS	-	-	-	-	-	-	-	-	-	-	-	(*)	-	-	-	-	-	-	-	-	-
FA-oddball (1,50)	C x group	-	-	-	(*)	-	-	**	**	(*)	-	(*)	-	*	*	-	-	(*)	-	-	*	-
	C x GSS	(*)	-	(*)	*	-	-	*	(*)	-	-	-	(*)	-	-	-	-	-	-	-	-	-
	C x GSS x group	-	-	-	-	-	-	-	-	-	*	-	-	-	-	-	*	-	-	*	-	-

group = low and high groups of corresponding variables (TS, Im-Re, RW, FA-DRM, FA-oddball)

C x GSS x group does not show in some variables, meaning that they did not have significant interactions.

From Table 21, the old/new difference is seen at most scalp areas and intervals, but most prominently and reliably at frontocentral, centroparietal, and right temporoparietal locations, particularly during the late (700-1100 ms) interval.

There were significant interactions of Condition and Group in most of the regions of interest. This indicates that there were differences of ERP patterns for extremely low and extremely high groups of TS, related variables and memory performance.

Individual differences in memory performance, indexed by DRM and GSS free recall, and to some extent by DRM false alarms, were reflected in an early (250-350 ms) ERP old/new effects, particularly at left temporoparietal, frontocentral, and orbitofrontal areas where poor memory performers showed a lack of ERP old/new diference (see also Figure 14b for RW: DRM-free recall).

Individual differences in oddball task performance were reflected in both early and middle (350-700 ms) latency ERP old/new effects. A lack of ERP old/new difference in poor performers was seen most clearly in right prefrontal and frontocentral areas (see also Figure 15b).

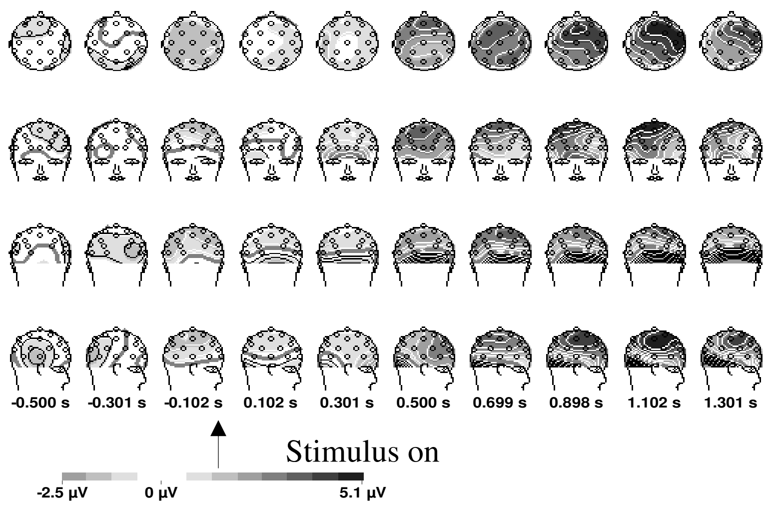
Individual differences in Interrogative Suggestibility were reflected in the late ERP old/new interval (700-1100 ms), particularly frontocentral and to some extent at the right prefrontal area (see also Figure 13b).

The discussion will be based on ANOVA results; however, to see the old/new differences in details, paired t-tests were performed between old/old and new/new conditions separately for high and low groups of variables on areas and intervals of interest to compare the old/new effects of significant (C x group) interactions.

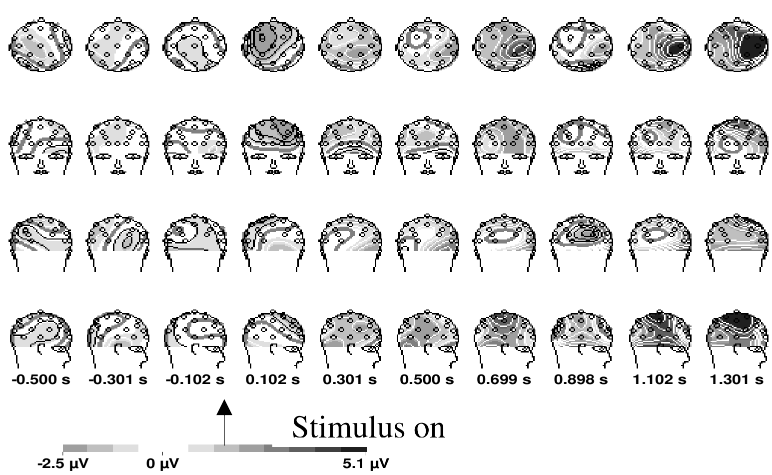
Scalp topography and old-new effects for low and high TS individuals of collapsed GSS1 and GSS2 are shown in Figure 13 (a and b, N=26 each).

Figure 13a Scalp topography of low and high TS individuals of collapsed GSSs. Darker shaded areas indicate greater old/new differences.

Low TS



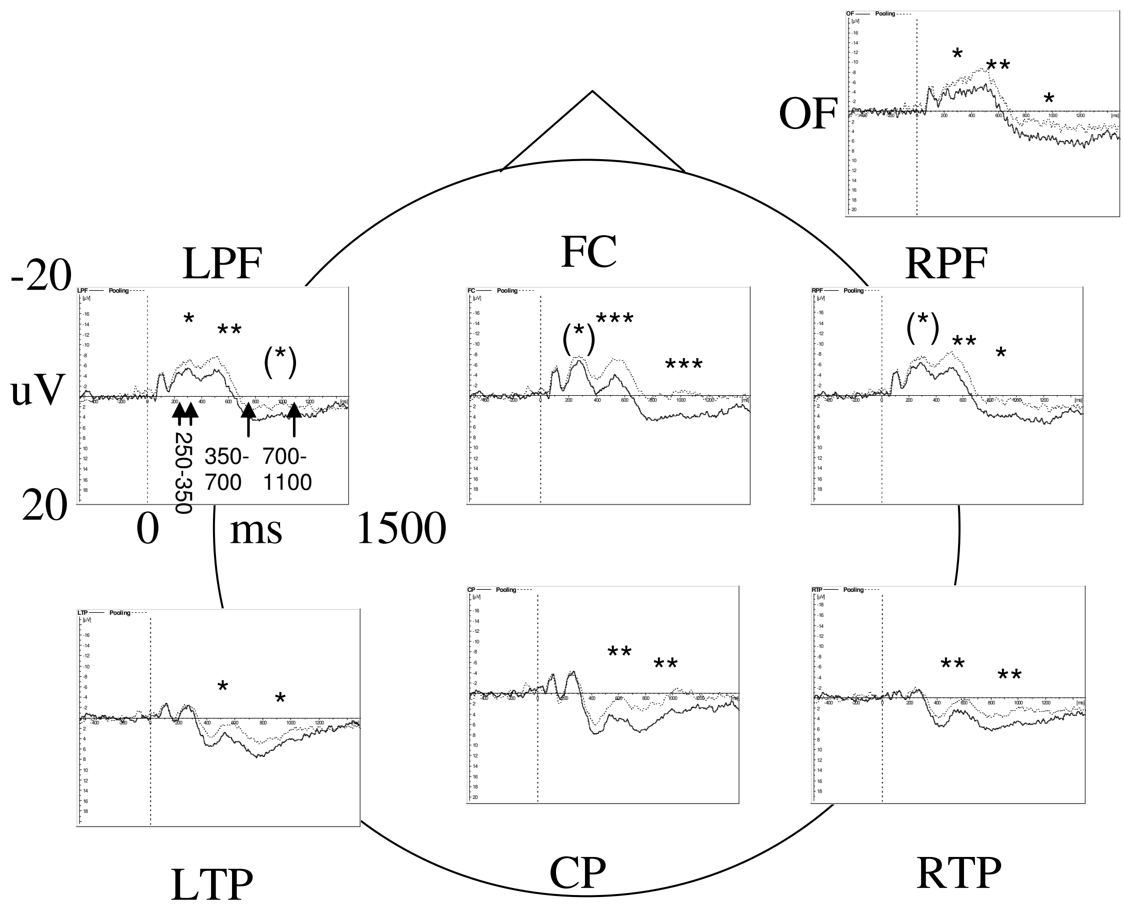
High TS



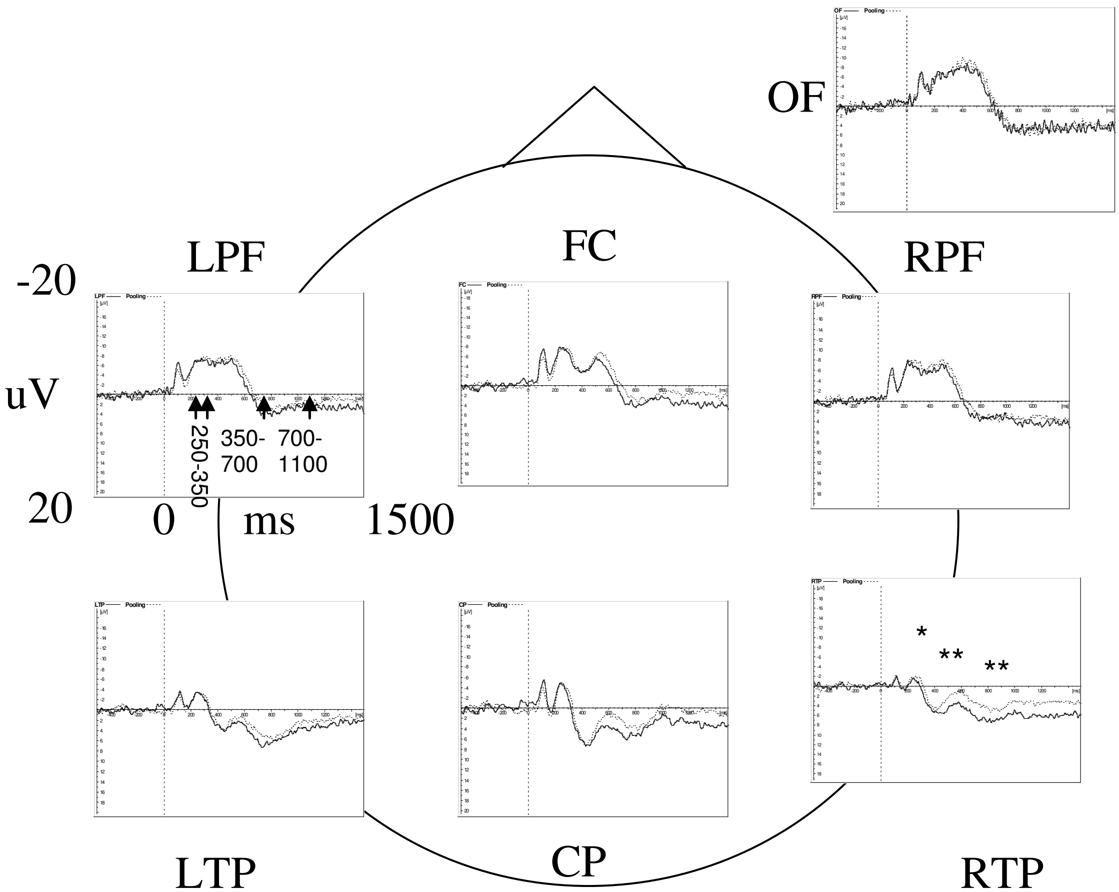
From the topography it may be seen that in low suggestible participants, a frontocentral old/new difference develops around 500 ms and spreads laterally and posteriorly to involve centroparietal regions, reaching a maximum value at around 1100 ms. The old-new differences were less clear in high suggestible participants.

Figure 13b ERP old/new effects at regions and intervals of interest in TS groups of collapsed GSS1 and GSS2 (old/old=solid line, new/new=dotted line), (*)p<.1, *p<.05, **p<.01, ***p<.001

Low TS



High TS



From the grand averages, the difference between high and low suggestible participants occurred during the 250-1100 ms interval at most regions of interest, where the low suggestible participants showed significant old/new differences, but the high suggestible participants did not (except for a region of right temporal that both low and high suggestible individuals showed significant old/new effects).

Participants were also contrasted by memory performance (good vs. poor performance groups) in DRM free recall and false alarms, GSS Immediate and Delayed Recall, and compared in terms of old/new ERP effects. As shown in Chapter 3, the memory measures were all significantly intercorrelated, so there was some degree of overlap between groups. Not surprisingly, therefore, the same pattern of differences emerged regardless of which memory measure was used to contrast good and poor performers. Some prominent results are shown in the followings.

Scalp topography and old-new effects of old/new effects for low and high RW individuals of collapsed GSS1 and GSS2 are shown in Figure 14 (a and b, N=27 each).

Figure 14a Scalp topography of low and high RW individuals of collapsed GSS1 and GSS2. Darker shaded areas indicate greater old/new differences.

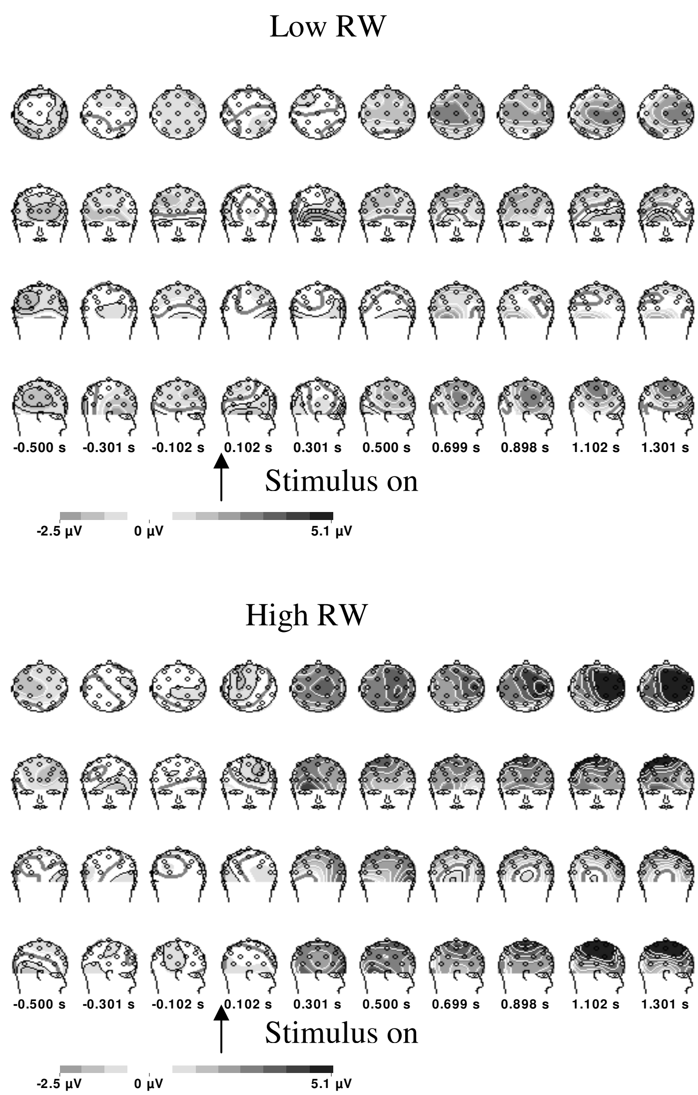
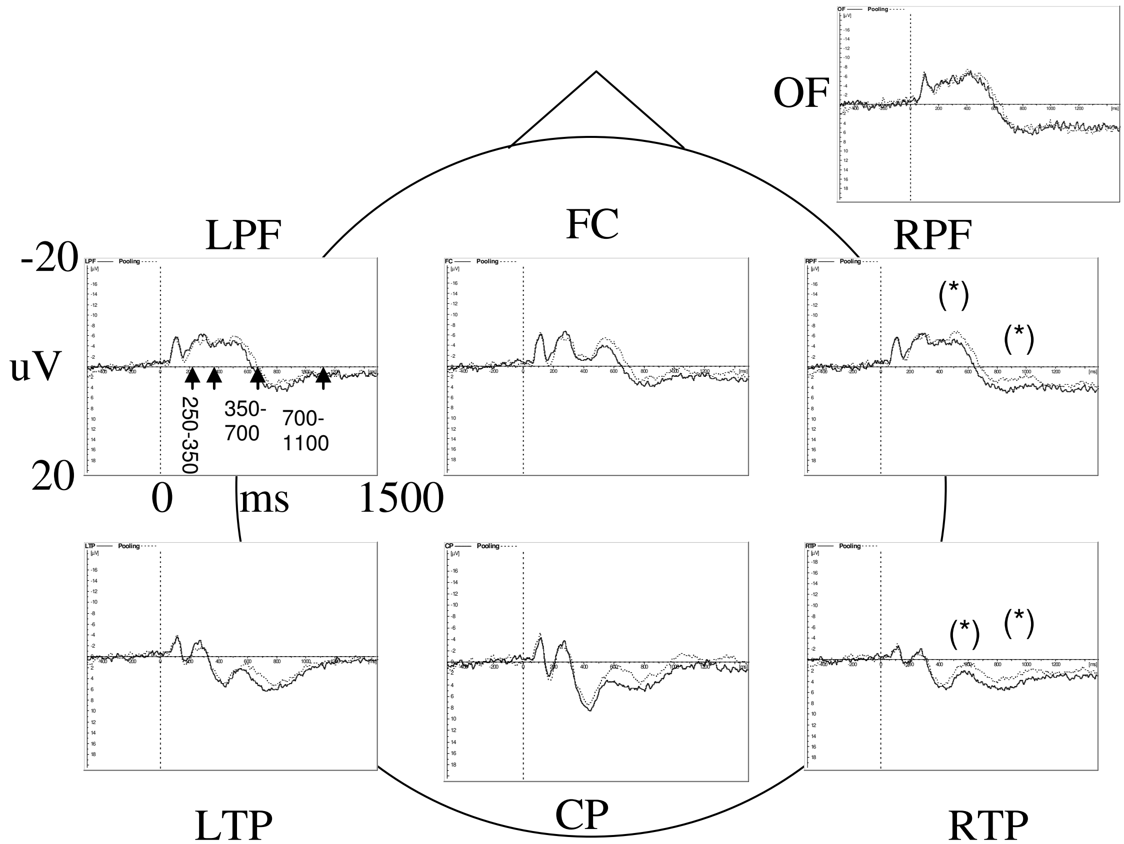
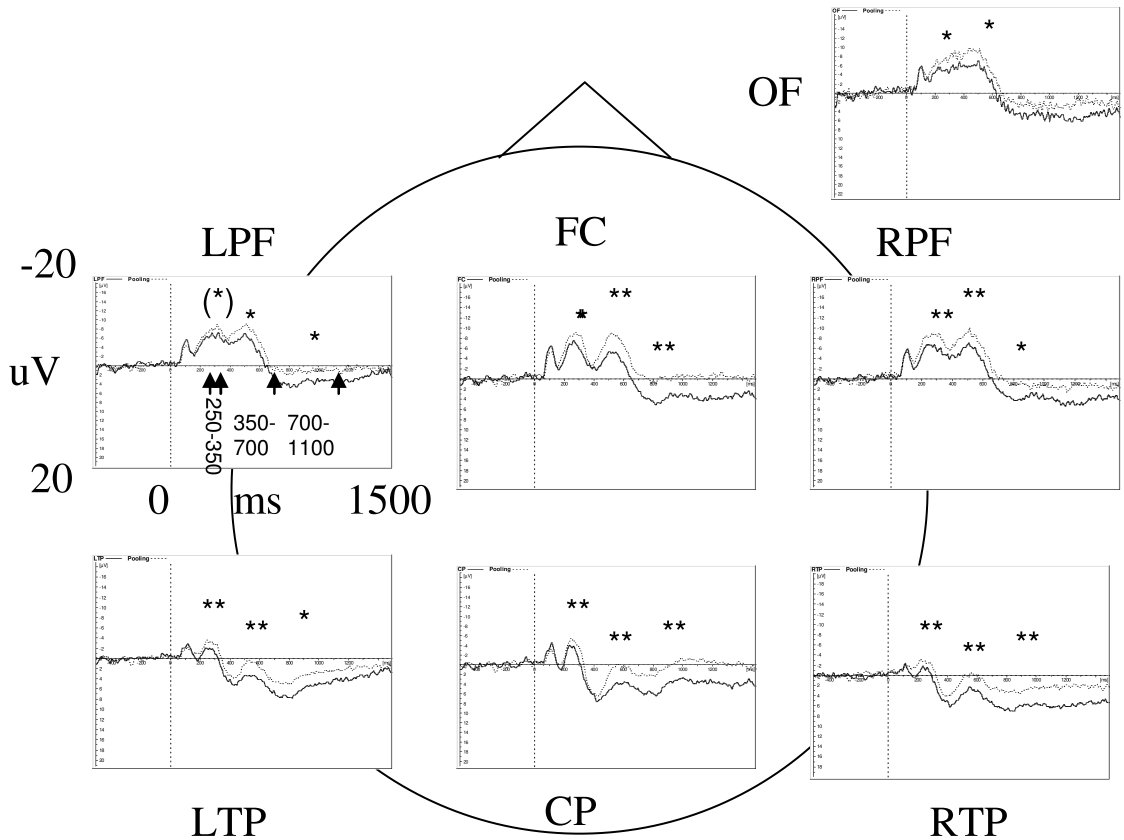


Figure 14b ERP old/new effects of low and high RW individuals of collapsed GSS1 and GSS2

Low RW



High RW

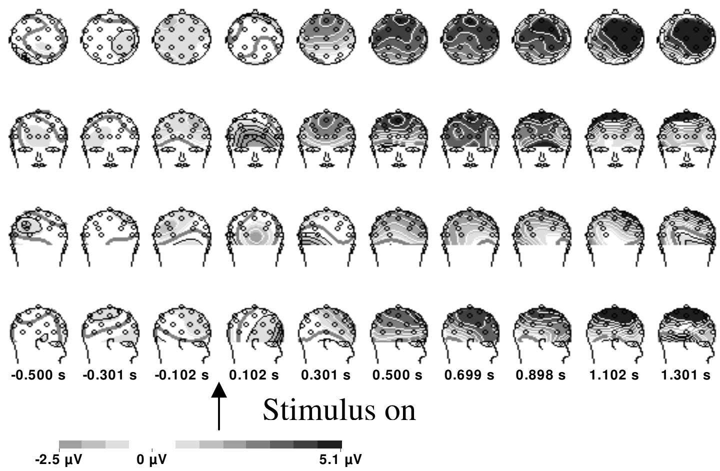


From Figure 14, old/new effects were more clearly seen and statistically reliable in high RW individuals than low RW individuals at all regions and intervals of interest.

Scalp topography and regions of interest of old-new effects for low and high FA (oddball) individuals of collapsed GSS1 and GSS2 are shown in Figure 15 (a and b, N=27 each).

Figure 15a Scalp topography and old-new effects of low and high FA (oddball) individuals of collapsed GSS1 and GSS2. Darker shaded areas indicate greater old/new differences.

Low FA (oddball)



High FA (oddball)

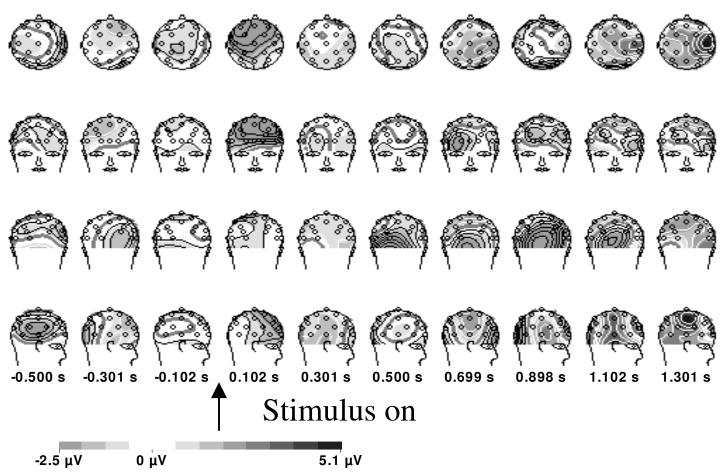
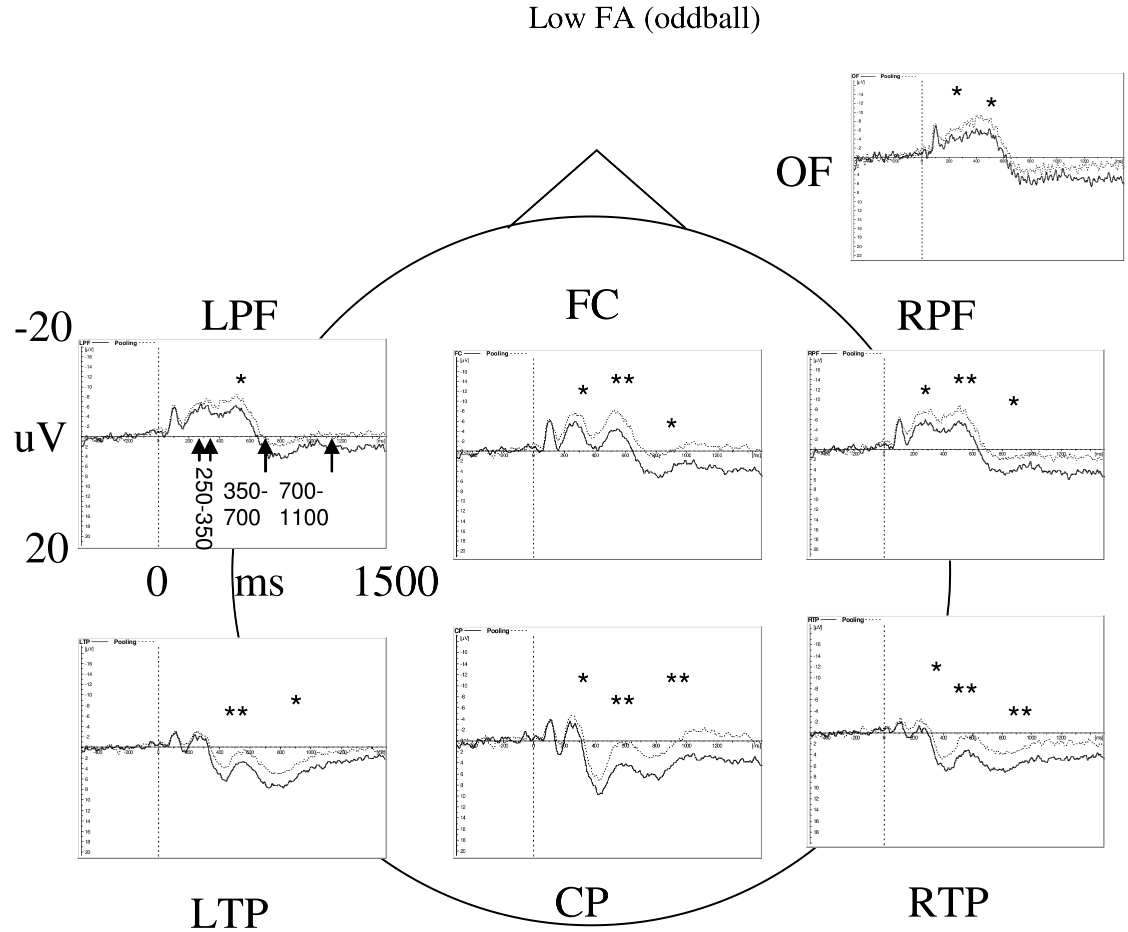
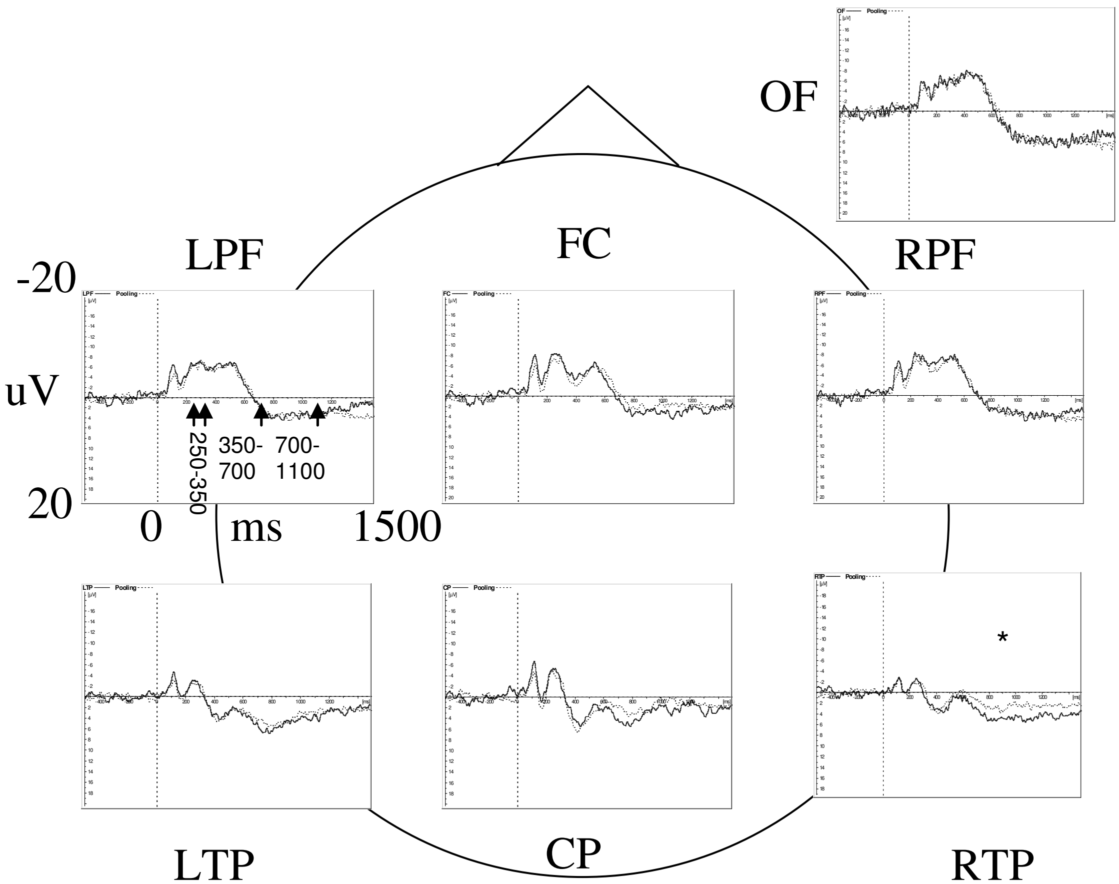


Figure 15b ERP old/new effects of low and high FA (oddball) individuals of collapsed GSS1 and GSS2



High FA (oddball)



From Figure 15, old/new effects were more clearly seen and statistically reliable in low FA (oddball) individuals than high FA (oddball) individuals at most regions and intervals of interest.

From Table 21, there were C x GSS interactions for RW-DRM and FA (oddball) variables and C x GSS x group for Immediate recall and FA (oddball) individuals. These indicate that C or C x group effects were moderated by GSS versions. Differences in ERP old/new effects comparing high RW with low RW, and high FA with low FA, were much more evident in GSS1 than in GSS2 as shown in the following topographical maps, Figures 16-19.

Figure 16 Scalp topography and old-new effects of low and high RW individuals of GSS1 (N=13 each). Darker shaded areas indicate greater old/new differences.

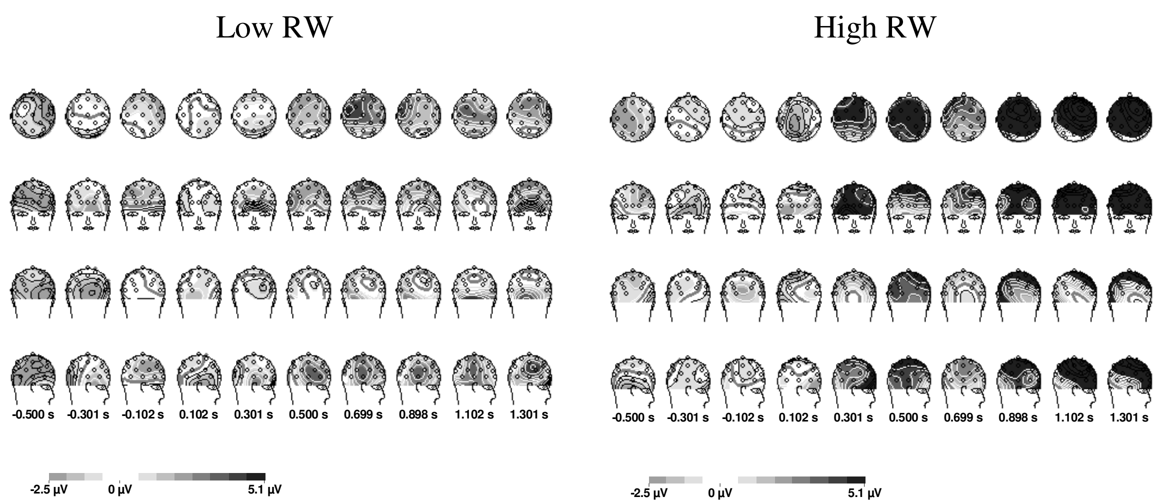
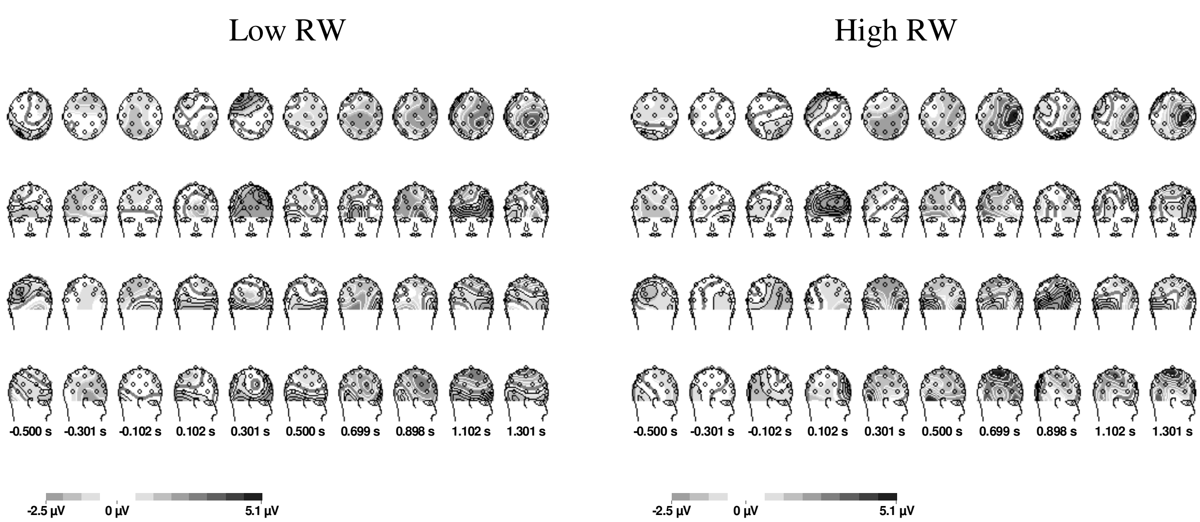


Figure 17 Scalp topography and old-new effects of low and high RW individuals of GSS2 (N=14 each). Darker shaded areas indicate greater old/new differences.



From Figure 16-17, ERP old/new differences were more clearly seen in high RW individuals of GSS1 than high RW individuals of GSS2.

Figure 18 Scalp topography and old-new effects of low and high FA(oddball) individuals of GSS1 (N=13 each). Darker shaded areas indicate greater old/new differences.

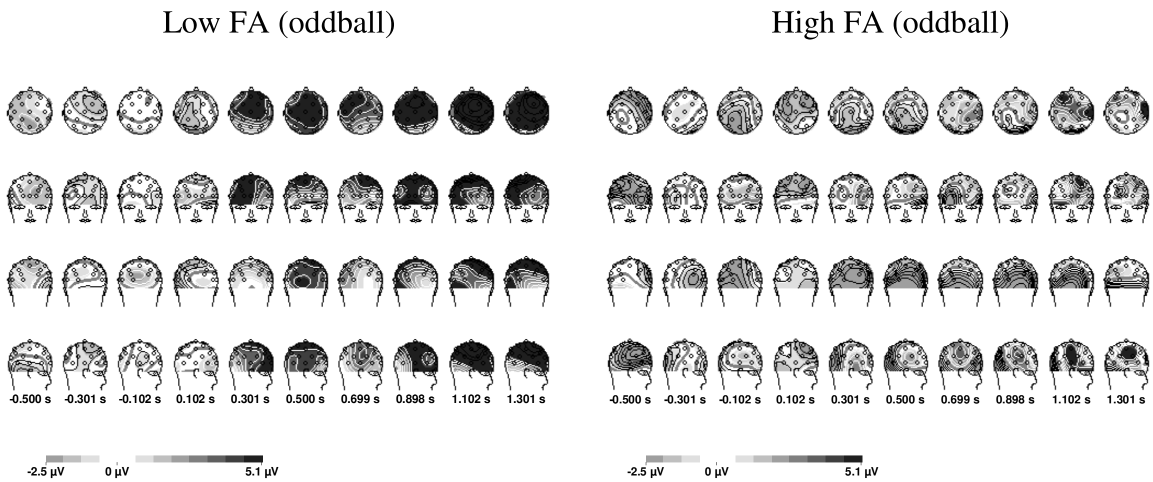
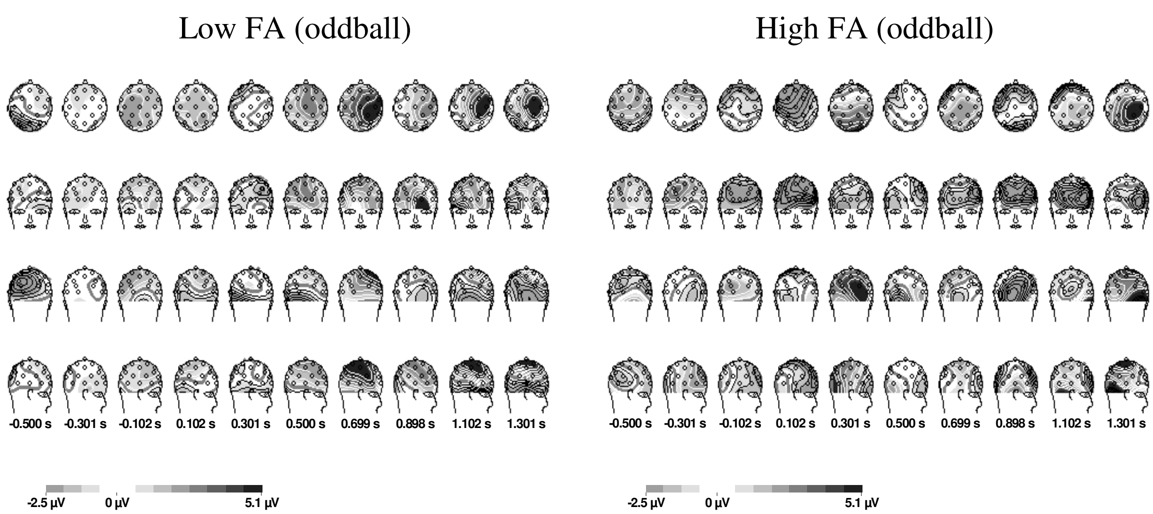


Figure 19 Scalp topography and old-new effects of low and high FA(oddball) individuals of GSS2 (N=14 each). Darker shaded areas indicate greater old/new differences.



From Figure 18-19, ERP old/new effects were more clearly seen in low FA (oddball) individuals of GSS1 than low FA (oddball) individuals of GSS2.

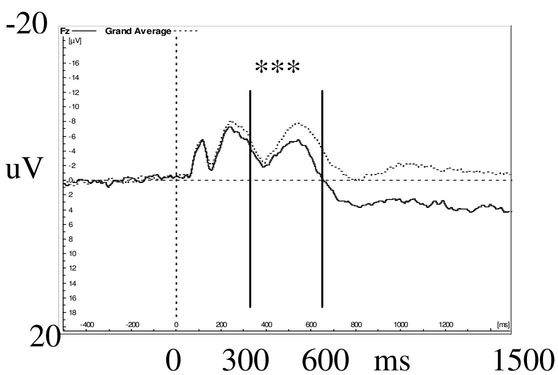
In conclusion, low suggestible, low false alarm, and good memory individuals tended to show significant old/new effects for all regions and intervals of the scalp. In contrast, high suggestible, high false alarm, and poor memory individuals did not show significant old/new effects.

<u>ERP old/new effects following Mecklinger's paradigm</u>

Early frontal (Fz, 300-600 ms), parietal (Pz, 400-800), and late right prefrontal (F8, 800-1450 ms) old/new ERP effects (Mecklinger's (2000) model) were examined. Significance levels derived from paired t-tests were shown for each ERP graph.

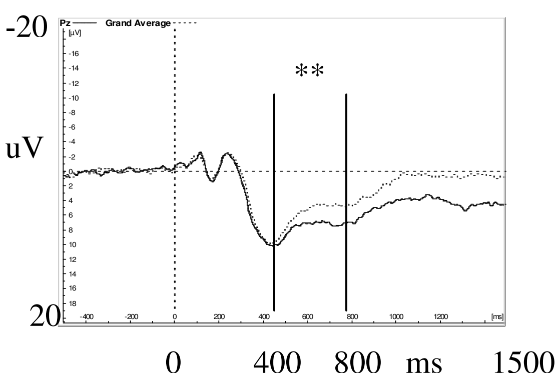
Figure 20 ERP old/new effects following Mecklinger's (2000) of overall participants (N=84, males and females), ***p<.001, **p<.01

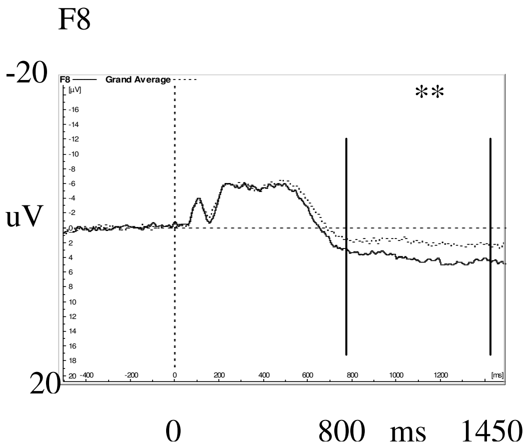
Fz



——— old/old
……… new/new

Pz





For female participants, (2C x 2GSS) ANOVAs were performed to see the overall results, and then, low and high groups of IS, memory performance and variables of interest were compared using three-factor repeated measure ANOVAs (2 C x 2 GSS x 2 group-high/low) at the three old/new effects. The results are shown in Table 22.

Table 22 Summary of results of [2 C x 2 GSS x 2 Groups (high, low)] ANOVAs following Mecklinger's model.

Variable (df)	Source	Fz	Pz	F8
Overall (1,63)	C C x GSS C x GSS x group	*** -	* -	* -
TS (1,48)	C x group C x GSS C x GSS x group	- - -	- - -	- - -
Yield1 (1,52)	C x group C x GSS C x GSS x group	- - -	- - -	- - -
Shift (1,48)	C x group C x GSS C x GSS x group	- * -	- - -	- - -
Im-Re (1,48)	C x group C x GSS C x GSS x group	- - -	- - -	- (*) -
RW-DRM (1,50)	C x group C x GSS C x GSS x group	- - -	- - -	- - -
FA-DRM (1,52)	C x group C x GSS C x GSS x group	- - -	- - -	- - (*)
FA-oddball (1,50)	C x group C x GSS C x GSS x group	* - -	- - -	- - -

Overall, significant old/new effects were shown for all three old/new effects. However, there was a significant (C x group) interaction only the FA (oddball) variable at Fz. This indicates that low and high FA (oddball) showed different old/new differences. A post-hoc analysis by a paired t-test found that low FA (oddball) showed stronger frontal old/new effects ($p<.01$). For other variables, there were no significant differences between low and high groups for all of the three old/new effects based on Mecklinger's model.

There was a (C x GSS) interaction for Shift at Fz. There was a marginally significant (C x GSS) interaction of Immediate Recall at F8 and a marginally significant (C x GSS x group) interaction of DRM-FA at F8. These again indicate that GSS1 and GSS2 were different for some extent in ERP old/new effects.

Summary of Results and Discussion

From the present results, ERP correlates of memory confirm a relationship between individual differences in IS and differences in neurocognitive processing as related to memory. The results can be concluded into three aspects.

First, individual differences in IS were reflected in the late ERP old/new interval (700-1100 ms), particularly frontocentral and to some extent at the right prefrontal area which was related to post-retrieval evaluation effects. Curran et al. (2001) found that good performers, not poor performers, showed late right frontal ERP differences between new items and studied items or lures. They suggest that good performers may have more efficient post-retrieval evaluation processes. This can be applied to the present study that low suggestible individuals had more efficient post-retrieval evaluation processes than high suggestible individuals because low suggestible individuals showed bigger old/new effects. It also supported the hypothesis that the post-retrieval evaluation is engaged by prefrontal cortex to generate and maintain a representation of the study episode and to allow the information to be used in a goal-directed way (Allan et al., 1998). This is because low suggestible individuals showed better memory performance and more significant old/new differences, when compared to high suggestible individuals. In addition, the present result is consistent with some researchers in that the greater the amount of information recalled, the larger is the magnitude of the right prefrontal old/new effects (e.g. Donaldson & Rugg, 1998). However, the results from the present study did not support the hypothesis that when information supporting a recognition judgement was relatively poor, such as in the absence of recollection, or when few retrieval products are available, monitoring operations or retrieval attempt would be engaged to a greater extent than when information was less ambiguous (Henson et al., 1999). It also did not support the Cabeza et al. (2001) who found that false recognition produced greater activation in right ventromedial prefrontal cortex than true recognition, although they explained the right prefrontal old/new effects as the engagement of monitoring processes that are demanding when participants attempt to judge “old or new”. This is because the present study found that good performers (low false alarm, high memory recall) tended to show more significant right frontal old/new effects.

Second, individual differences in memory performance, indexed by DRM and GSS free recall, and to some extent by DRM false alarms, were reflected in an early (250-350 ms) ERP old/new effects, particularly at left temporoparietal, frontocentral, and orbitofrontal areas where poor performers showed a lack of ERP old/new difference.

Third, Individual differences in oddball task performance were reflected in both early (250-350 ms) and middle latency (350-700 ms) ERP old new effects. A lack of ERP old/new difference in poor performers was seen most clearly in right prefrontal and frontocentral areas.

From Table 21, there are Condition x GSS interactions in some variable and some regions of interest. Post-hoc analyses showed that GSS1 showed more clear and reliable old/new differences than GSS2.

In the next chapter, the ERP results pertaining to the possibility that individual differences in attention underlying differences in IS will be presented.

Chapter 6

Result 4: ERP Indices of attention: their relationship to individual differences in interrogative suggestibility (IS)

Prologue:

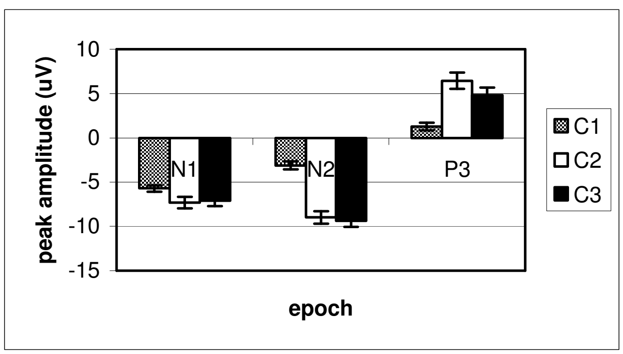
The presentation of ERP results pertinent to the hypothesis relating individual differences in IS to differences in attention will be presented. ERPs recordings were time-locked to old (related to the GSS story; Condition 2) and new (unrelated to the GSS story; Condition 3) events. Suggestible individuals, being characterized by a diffuse and unfocused attentional style, will allocate fewer attentional resources to target stimuli (in this case, potentially story-relevant pictures, Conditions 2 and 3) and more attentional resources to irrelevant non-targets (geometric shapes). This should manifest, in terms of ERP amplitudes, as larger ERPs to non-targets and smaller ERPs to targets in suggestible, relative to non-suggestible, individuals.

Results

To compare the overall ERP differences of GSS1 and GSS2, a three-factor repeated measure ANOVA (4 Ch x 3 C x 2 GSS) was performed for female participants [GSS1 (N=30) and GSS2 (N=35)] using midline electrode sites and stimulus conditions as within subject variables, and GSS as a between subject variable on peak amplitudes and latencies of the ERP epochs that are supposed to related to attention effects (N1, P2, N2, P3) as dependent variables. The peak amplitudes were derived from the peak components of individuals which have slightly different latencies across participants; however, the ERP grand averages were derived from the grand average voltages which have the exact latencies. The peak amplitude results showed a main effect of Condition for N1 [$F(2,126)=5.45$, $p<.001$], N2 [$F(2,126)=67.67$, $p<.001$], and P3 [$F(2,126)=23.08$, $p<.001$]. The latency results showed a main effect of Condition for N1 [$F(2,126)=4.28$, $p<.05$], P2 [$F(2,126)=27.59$, $p<.001$] and N2 [$F(2,126)=2.85$, $p<.1$]. There were no other significant main effects or interactions in both peak amplitudes and latencies. There were no GSS interactions, this indicates that the overall results of GSS1 and GSS2 for attention effects were not different.

Since, there were no interactions of channel x GSS x C, peak amplitudes of each epoch (except P2 due to no main effect of condition for amplitudes) at each condition of collapsed midline channels and GSSs were performed. The results are shown in Figure 21.

Figure 21 Peak amplitudes of each epoch, data are collapsed across midline channels and GSSs (N=65)



Results for N1, N2 and P3 may be seen that amplitudes were larger in the target conditions (Conditions 2 and 3) than in the non-target condition (Condition 1). Condition 2 evoked a larger P3 than did Condition3 and the difference was significant ($t\ (64) = 2.33$, $p< .05$). This is attributable to the old/new difference occurring during the P3 interval (Condition 2 was old, Condition 3 was new).

A [4 Ch x 3 C x 2 group (low, high)] ANOVA was performed on peak amplitudes of TS at each peak, collapsed across GSS1 and GSS2 (N=26 in each group). The same significant main effects of Condition were obtained. There were a main effect of Condition for N1 [$F(2,100)=3.41$, $p<.05$], N2 [$F(2,100)=65.77$, $p<.001$], and P3 [$F(2,100)=23.65$, $p<.001$] but there were no other main effects or interactions, and in particular none involving Group. There were no significant interactions of Condition and group for TS individuals. This indicates that low and high suggestible individuals were not different in terms of attention effect. In sum, there was no indication in the ERP data that high suggestible individuals were deploying attentional resources any differently from low suggestible individuals.

Analysis of GSS1 and GSS2 separately also did not find significant interactions of condition and group for TS individuals in either GSS1 or GSS2.

For other variables of IS and related variables also produced the same trends of results; namely, no attention effects were found for low and high groups of these variables. Since ERPs were not different between GSS1 and GSS2, ERPs of low and high TS individuals were collapsed across GSS1 and GSS2 as follows:

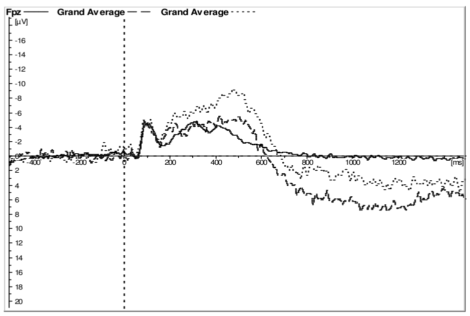
Total Suggestibility Grouping (TS)

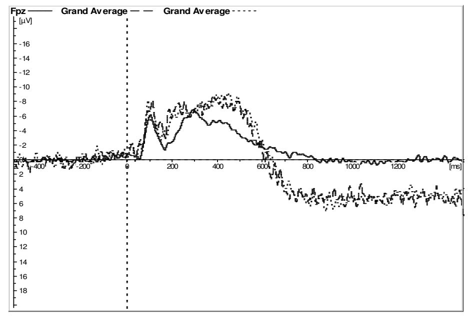
ERP grand averages of low and high TS individuals of collapsed GSS1 and GSS2 are shown in Figure 22.

Figure 22 ERP grand averages of low and high TS individuals of collapsed GSS1 and GSS2 for the midline sites of 3 conditions (Condition1=solid line, Condition2=dashed line, Condition3=dotted line)

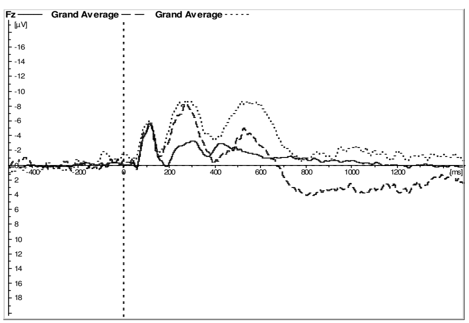
——— Condition 1
------- Condition 2
…….. Condition 3

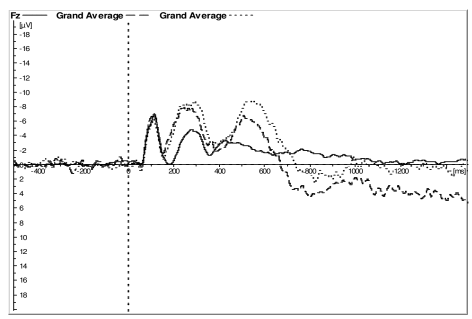
Fpz low TS high TS



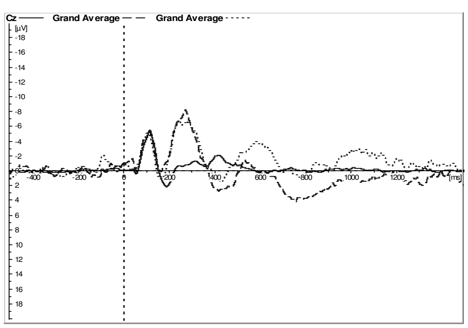


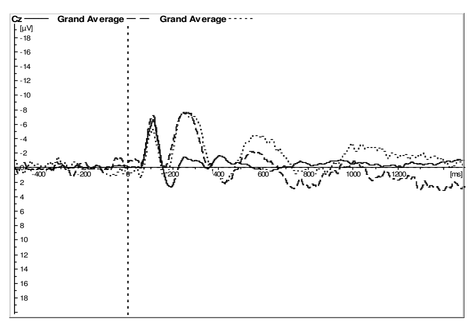
Fz



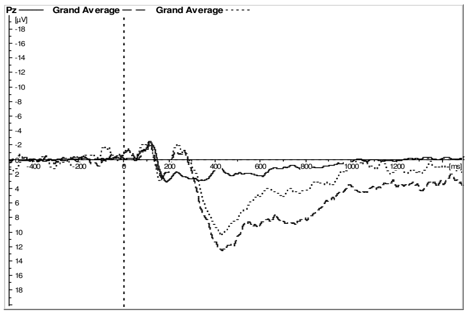


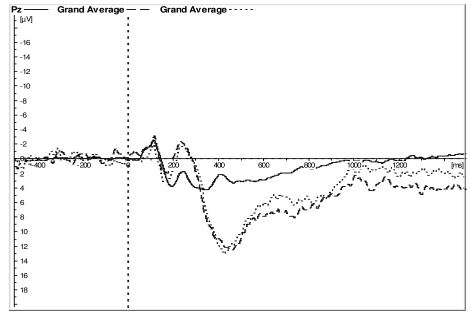
Cz





Pz





Analysis of variance using mean amplitudes as the dependent variable also produced the same results as using peak amplitudes. In short, there was no indication in the ERP data that high suggestible individuals were deploying attentional resources differently from low suggestible individuals.

<u>Conclusions and discussion</u>

Consistent with the idea that the 3-stimulus oddball paradigm engaged attention to potential targets (conditions 2 and 3) relative to non-targets (condition 1), ERP amplitudes (particularly for N2 and P3) were larger for targets than non-targets. This result is unsurprising. More interestingly, the present results provide no evidence that suggestible participants differed from non-suggestible participants in terms of ERP correlates of attention to targets vis-à-vis non-targets. This result disconfirms the attention hypothesis relating to individual differences in IS; insofar as it suggests that high and low suggestible individuals do not differ in their allocation of attentional resources to task-relevant vis-à-vis task-irrelevant stimuli. This does not, however, definitively exclude an explanation of IS in terms of attention. This will be further discussed in the final chapter.

Chapter 7

Discussion and Conclusions

From the results of the present study, the research questions and hypotheses that posed in Chapter 1 can be answered as follows.

<u>Interrogative Suggestibility (IS) and memory</u>

Memory measures (GSS free recall) and Yield (including TS) measures were highly negatively correlated. This means that participants who have lower memory capacity, tend to yield more to the leading questions. However, Shift and memory measures were not significantly correlated. The GSS data confirm previous reports (Gudjonsson, 2003; Polczyk, 2005) of an inverse relationship between GSS memory performance (immediate and delayed recall) and IS. The results and those obtained previously (e.g. Howard and Goh, 2002) suggest that it is the Yield component of IS that bears the weight of this relationship. In addition, DRM-FA had a positive correlation with Total Suggestibility. This indicates that people who made more false alarms tended to be more suggestible or vice versa. For the correlations between GCS and other memory measures, there was a correlation between GCS and DRM-free recall only in GSS1.

However, the correlations between memory (both recall and recognition) and interrogative suggestibility were not strong, when other measures of memory (e.g. DRM) were used. Therefore, an alternative hypothesis that Interrogative Suggestibility is not related to memory, but to context-specific factors, as suggested by Bruck & Melnyk (2004) seemed to be possible, when self-report measures were used. However, further experiments using ERPs confirmed that ERP old/new effects (recognition memory) were different between low and high groups of Total Suggestibility and between good and poor memory performers (DRM-free recall). Therefore, that Interrogative Suggestibility is not related to memory, but to context-specific factors, as suggested by Bruck & Melnyk (2004) could be arguable. ERPs could be shown to be different between low and high suggestible individuals in terms of recognition memory effects (ERP old/new effect).

Interrogative Suggestibility, memory and attention: ERP old/new effects

This study used a 3-stimulus oddball paradigm to study the relationship between IS, memory (especially recognition retrieval) and attention. Howard and Ng (2002) suggested that suggestible individuals may be characterised by a diffuse, unfocused attentional style, making them susceptible to distracting, task irrelevant stimuli. In contrast, non-suggestible individuals would focus their attention more efficiently on task-relevant stimuli. However, the hypothesis in terms of attentional differences was disconfirmed. ERP components related to attention, in particular N1/N2/P3, showed a significant main effect of task condition, indicating increased allocation of attention to task-relevant stimuli, but no significant Group x Condition interaction. This strongly suggests that suggestible participants did not differ from non-suggestible participants in their response to task-relevant vis-à-vis task irrelevant pictures. In addition, suggestible and non-suggestible individuals were not different in their behaviour in the oddball task, both in terms of accuracy and reaction times.

In contrast, results of this study supported, the hypothesis that suggestible individuals suffer from poor memory, supporting the idea of “memory distrust” syndrome in highly suggestible individuals (Gudjonsson, 2003). Firstly, there is an inverse relationship between GSS memory performance (immediate and delayed recall) and IS (albeit, the relationship between DRM-free recall and IS are not promising). Secondly, suggestible individuals, contrasted with non-suggestible, individuals showed a significant lack of ERP old/new effects during the late (700-1100 ms) interval of the ERP epoch, particularly at frontocentral and right prefrontal areas.

Interpretation of the latter finding rests on an understanding of the functional significance of the late right prefrontal old/new effect which, as discussed by Friedman and Johnson (2000), is far from clear. Mecklinger (2000) suggests that such late-onset effects reflect the engagement of cognitive operations set by the retrieval context, and that successful recollection does not seem necessary for their elicitation. Similarly, Curran, Schacter, Norman, and Galluccio (1997) described a patient who had a right prefrontal lobe lesion committed excessive recognition false alarms in which the authors explained it as deficient monitoring of memory retrieval. Allan et al. (1998) suggest that a right prefrontal old/new effect reflects processes that contribute to the integration and maintenance of retrieved information, allowing the information retrieved to be used in a goal-directed way. Curran et al. (2001) also suggest that good performers may have more efficient post-retrieval evaluation processes that are associated with the right frontal old/new effects. A similar notion was expressed by Buckner and Wheeler (2001) when they suggest that right anterior frontal-polar cortex is particularly engaged when, metaphorically speaking, we navigate between the present and the past. This is precisely what is required of participants in the oddball task used in the present study: presented with story-relevant and story-irrelevant pictures, they have to decide which relate to their past experience of hearing the GSS story (old pictures), and which do not (new pictures).

Impairment in this ability to navigate between present and past may be the source of the memory difficulties of suggestible people. In addition, positron emission tomography studies (e.g. Tulving et al., 1994) have revealed that right frontal regions are more activated during episodic retrieval of recently studied items than during encoding. Schacter, Kagan, and Leichtman (1995) suggest that the activation of right frontal regions during episodic retrieval reflects the search processes that are defective in a patient of false recognition responses.

In contrast to IS, individual differences in memory performance, in particular free recall, were reflected in differences in the early (250-350 ms) interval. These differences were consistent across different measures of free recall (DRM and GSS) at left temperoparietal, frontocentral and orbitofrontal scalp. They were also replicable across the two versions of GSS (GSS1 and GSS2). Like the other memory measures, DRM-FA were reflected in early (250-350 ms) old/new differences, albeit this was a statistically marginal effect (see Table 21). The onset of this early old/new effect is rather earlier than that typically found in studies that have used traditional verbal recognition paradigms: Allan, et al. (1998), for example, reported onsets typically occurring at 350-450 ms post-stimulus, and Mecklinger's (2000) earliest old/new effect, the medial frontal effect said to be associated with familiarity assessment, occurs at 300-500 ms post-stimulus. Friedman and Johnson (2000), in contrast, reported old/new effects with onsets as early as 200 ms. It is perhaps not surprising that the current paradigm, which (unlike traditional verbal recognition paradigms) tested memory implicitly rather than explicitly, should have produced old/new effects that are different, in latency and morphology, from those found using standard verbal recognition paradigms.

Individual differences in behavioural performance in the oddball task (making false alarms), in contrast, were associated with differences in both early (250-350 ms) and middle (350-700 ms) latency components of the old/new difference. Since oddball false alarms correlated positively and significantly with some memory measures (e.g. with DRM false alarms $r=.30$, $p<.01$, see Table 15, Chapter 3), some commonality of effect on the old/new difference is to be expected. More interesting is the finding that oddball performance was associated with differences in the middle latency part of the old/new difference that was not associated with individual differences in memory performance. While the precise functional significance of these ERP old/new differences occurring at different latencies remains to be determined, it seems clear from the present results that old/new differences having different latencies are differentially sensitive to various individual difference variables: IS, memory performance and behavioural performance.

Although the present results supported an account of individual differences in terms of memory rather than attention, it should be borne in mind that, in the context of the “misinformation effect” described by Loftus and colleagues (e.g. Gerrie, et al., 2004), the ability to detect discrepancies between an event and misleading post-event information is said to be a function of both memory for the event and the amount of attention paid to the misleading information. While the current results certainly support the role of memory strength as an individual difference variable in IS, an alternative possibility needs to be considered in relation to individual differences in attention:

namely, that suggestible individuals were, at study (i.e. when they listened to the GSS story) more distracted or distractible than non-suggestible individuals. Curran (2004) has recently shown, in support of the dissociation of frontal familiarity and parietal recollection old/new effects, that the parietal old/new effect can be reduced under conditions of divided attention at study, while the frontal old/new effect was unaffected by the attention manipulation. The possibility must be considered that the critical difference, in terms of attention, between suggestible and non-suggestible individuals was a lack of attention to the GSS story on the part of high suggestible individuals. Further studies are required to clarify this issue. In addition, one should bare in mind that memory and attention are always intercorrelated. If attention is divided, memory is affected.

In addition, more research in differences of encoding processes between low and high suggestible individuals are required. Okado and Stark (2004) have recently shown that encoding processes play a critical role in determining true and false memory outcome in misinformation paradigms. Therefore, differences between suggestible and non-suggestible individuals may be because of their differences in encoding processes.

Interrogative Suggestibility and memory following Mecklinger's (2000) model

While this study was not designed to test Mecklinger's (2000) neurocognitive model of recognition memory, clear old/new effects were seen during ERP epochs and at electrode sites corresponding to the three types of old/new effect specified in his model: familiarity assessment, recollection/retrieval success and post-retrieval evaluation. However, the present results suggest, consistent with Friedman and Johnson (2000), that ERP old/new effects may represent longer lasting and more dynamic processes than those implied by Mecklinger’s model. It must be borne in mind that Mecklinger’s (2000) model is based largely on studies that have used a traditional verbal recognition paradigm, unlike the present study that used a 3-stimulus oddball paradigm.

Analysis of variance performed on old/new ERP effects following Mecklinger’s (2000) model revealed that the three old/new effects did not differ significantly between low and high groups based on any variable, except only that high FA (oddball) individuals showed an absence of the frontal old/new effect (300-600 ms). This result is consistent with the present result of the lack of old/new effects at the frontocentral region at the 350-700 ms interval of high suggestible individuals. This suggests that high FA (oddball) individuals were deficient in familiarity assessment. However, recollection and post-retrieval processes appear to be intact in high FA (oddball) individuals. This may be because recollection and post-retrieval evaluation processes are not as vulnerable as the familiarity process. Wilding, Doyle, and Rugg (1995) suggested that recollection is a graded, rather than an all-or-none, process. Participants in the present study did not have extremely poor memories. In contrast, familiarity assessment as a process may be more variable and sensitive to inter-individual variation.

The analysis following Mecklinger’s model found that right frontal old/new effects were intact in high suggestible individuals. This is in contrast with the finding that right frontal old/new effects were absent in high suggestible individuals when analysed by region of interest. This may be because right frontal old/new effects examined following Mecklinger’s model used only one electrode (F8), whereas right frontal old/new effects examined using a cluster of electrodes covering the right prefrontal area would be expected to yield a more reliable result. Moreover, as pointed out above, Mecklinger's model was based on the traditional verbal recognition paradigm, while this study tested recognition memory implicitly. The nature of stimuli and tasks can affect the onset and duration of ERP old/new effects differentially (Friedman & Johnson, 2000). This may explain why Mecklinger's model was not well supported by the current paradigm for low and high suggestible individuals. However, it was clearly shown that high FA (oddball) individuals were impaired in frontal old/new effects in both analyses using Mecklinger's model or region of interest.

<u>Interrogative Suggestibility and personality</u>

For the overall results, there were no significant correlations between GSS suggestibility measures and personality variables (see Table 16), including no significant correlations of GCS and suggestibility measures (see Table 15), except Yield2 correlated modestly and negatively with agreeableness. This indicates that participants who were more agreeable tended to yield to the leading questions after negative feedback given which is consistent with the study from Liebman et al. (2004). Gudjonsson (2003) also reported poor correlations between IS and GCS data. In addition, GCS correlated negatively with extraversion and emotional stability. This means that neurotic introverts tended to be compliant. This is consistent with other studies (e.g. Gudjonsson, 1989; Coolidge et al., 2001).

What do we know now, as a result of having done the thesis that we didn't know before?

Perhaps the most important things are that individual differences in IS do seem to reflect differences in memory performance; that the difference in memory performance appears on the basis of the ERP results, to reflect particularly differences in post-retrieval evaluation (although we still lack sufficient knowledge about how ERP old/new effects at different intervals map on to different memory processes; therefore, one need to be guarded in one's interpretation of these findings).

Individual differences in IS do not appear to reflect differences in attention to task-relevant and task-irrelevant stimuli. However, attention and memory are not independent processes, an explanation in terms of attention to details of the GSS story is still possible.

Some Outstanding Questions and Directions for Future Research.

Are GSS1 and GSS2 really equivalent?

GSS1 and GSS2 are parallel forms that differ only in the narrative used and that yield, according to Gudjonsson (1997), very similar scores for IS and memory recall. Yet for the present study, both immediate and delayed recall were significantly higher, and Yield was significantly lower, in female participants undergoing GSS2 than in those undergoing GSS1 (see Table 12). This implies that GSS1 in comparison with GSS2 was more taxing on memory processes and created greater memorial uncertainty, at least in female participants. Furthermore, GSS1 suggestibility measures were more correlated with PEMQ data, whereas, GSS2 suggestibility measures were more correlated with DRM-FA data.

Another puzzling finding concerns the difference in ERP old/new effects comparing GSS1 with GSS2: ERP old/new effects were more apparent, and statistically reliable, for participants, who underwent GSS1 than for those who were tested using GSS2. The most plausible explanation for this is that old/new effects are associated with better behavioural performance, as we have shown here and as others have shown previously (e.g. Curran et al., 2001). Since oddball task performance was significantly more accurate in participants undergoing the GSS1 oddball procedure than in those undergoing GSS2, it would be expected (and the results confirm this) that ERP old/new effects would be more apparent in participants undergoing GSS1.

Are there sex differences in memory recall in GSS and DRM?

In the present study, there were sex differences in immediate recall and delayed recall of GSS2 in which females had more free recalls than males ($p<.05$). Furthermore, males had marginally more false alarms (oddball and DRM) than females in GSS2. In addition, there were sex differences in DRM-free recall in which females showed higher free recall than males (see Table 9, Chapter 3). One study by Redlich (1999 cited in Gudjonsson, 1997) did report GSS data suggesting that young males showed poorer immediate recall and higher suggestibility scores, a result that is consistent with those reported here in which males scored significantly lower than females on immediate and delayed recall. Furthermore, this is consistent with previous research (e.g. Lowe et al., 2003) which found that females outperform males on verbal tasks and males outperform females on spatial tasks. However, there were no significant results of immediate and delayed recall between males and females in GSS1. This may be due to a small number of males in GSS1.

Are there sex differences in ERP old/new effects related to Interrogative Suggestibility?

Another finding that merits further study, and replication, is the sex difference in ERP old/new effects. The ANOVA results showed some interactions of sex (see Table 19, Chapter 5). Within the neuroscience literature there is growing evidence for sex differences in memory (e.g. Guillem and Mograss, 2005; Gaab, Keenan and Schlaug, 2003; Speck et al., 2000; Trenerry, Jack, Cascino, Sharbrough and Ivnik, 1995). The ERP results of the present study would imply that a sex difference in old/new effect may be found. It seems females show a more marked early old/new effect (250-700 ms post stimulus onset) than males, especially at OF and RPF. Since it is the early effect that, according to the present study, relates most clearly with memory performance, this fits with the present findings that females show superior memory performance. Guillem and Mograss (2005) reported a sex difference in old/new effects, in which females showed larger old/new effects than males. Their old/new differences present as early as the N300 and last until the P600, and are clearly seen anteriorly. This is consistent with the result from the present study; however, their study used color photographs of persons' faces.

The possibility of a sex difference in GSS-measured IS clearly merits further study. The male sample in the present study was unfortunately too small to conduct an adequate comparison of males and females, and future studies should examine sex differences both in IS and in ERP old/new effects.

Limitations of the present study

This study has small numbers of relevant (or old, C2) and irrelevant (or new, C3) conditions because most of the trials were in condtion1 (80% distractors) due to the oddball paradigm used for capturing attention effects. Future research should increase the number of trials in Conditions 2 and 3.

In terms of the experimental paradigm, a divided attention manipulation could be employed at study (e.g. Curran, 2004). Participants could, for example, listen to the GSS story under conditions of divided or undivided attention prior to testing in the oddball paradigm. If individual differences in IS in part reflect differences in the manner proposed by Loftus and colleagues, then suggestible individuals would, under conditions of divide attention at study, be predicted to show a stronger reduction in the parietal old/new effect associated with recollection than non-suggestible individuals. Furthermore, encoding processes in relation to IS should be explored.

Finally, for the present study, both immediate and delayed recall were significantly higher, and Yield was significantly lower, in female participants undergoing GSS2 than in those undergoing GSS1; however, for the oddball task performance, it was significantly more accurate in participants undergoing the GSS1 oddball procedure than in those undergoing GSS2. This contradictory results may be because the differences in GSS story or GSS drawing pictures, namely, GSS1 has more details than GSS2 in which participants could remember the details of GSS2 more than those of GSS1, but when it comes to the drawing pictures, GSS1 pictures are more striking and easier to remember than GSS2 pictures (The GSS1 story is about the robbery during a woman's holidays, whereas, the GSS2 story is about a rescue of a boy who had spoiled brake of his bicycle). These differences of GSS stories and drawing pictures might produce the differences of GSS1 and GSS2 old/new effect results.

Concluding remarks

This study set out to test alternative explanatory accounts of individual differences in IS, in terms of attention and memory (especially recognition retrieval). Overall, the results support the memory explanation, but the two types of explanation are by no means mutually exclusive (indeed one recent ERP old/new study (Curran, 2004) demonstrates the interdependence of memory and attention). Future studies will be required not only to replicate the findings of the present study, but to address some interesting questions regarding encoding processes, sex differences, alternative explanations in terms of attention, and the equivalence of GSS1 and GSS2.

Finally, it should be recalled that more than 100 years have elapsed since Binet (1900) started this research enterprise by inducing IS and memory errors in French schoolchildren. ERPs and other brain imaging techniques, combined with sophisticated behavioural measures, are beginning, as shown here, to provide some tentative answers to the questions he originally addressed concerning the mechanisms underlying the differences in IS that he was the first to observe.

Bibliography

Aggleton, J. P., & Shaw, C. (1996). Amnesia and recognition memory: A re-analysis of psychometric data. *Neuropsychologia, 34,* 51-62.

Alexander, J.E., Porjesz, B., Bauer, L.O., Kuperman, S. Morzorati, S., O'Connor, S.J. et al. (1995). P300 hemispheric amplitude asymmetries from a visual oddball task. *Psychophysiology, 32(5),* 467-475.

Allan, K., Wilding, E. L., & Rugg, M. D. (1998). Electrophysiological evidence for dissociable processes contributing to recollection, *Acta Psychologica, 98,* 231-252.

Arthur, D. L., Lewis, P. S., Medvick, P. A., & Flynn, E. R. (1991). A neuromagnetic study of selective attention. *Electroencephalography and Clinical Neurophysiology, 78,* 348-360.

Asch, S. E. (1954). Effects of group pressure upon the modification and distortion of judgments. In H. Guetzkow (Ed.), *Groups, leadership, and men.* Pittsburgh: Carnegie Press.

Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In K. W. Spence & J. T. Spence (Eds.), *The psychology of learning and motivation: Advances in research and theory* (pp. 129-153). Hillsdale, NJ: Erlbaum.

Ayling, C. J. (1984). Corroborating confessions: an empirical analysis of legal safeguards against false confessions. *Wisconsin Law Review, 4,* 1121-1204.

Baddeley, A. D. (1999). Essentials of Human Memory. East Sussex: Psychology Press.

Binet, A. (1900). L'Interrogatoire. In La Suggestibilite [Suggestibility], pp. 299-414.

[On-Line]. Available: http://www.gutenberg.net/1/1/4/5/11453/11453-8.txt.

Bruck, M. & Melnyk, L. (2004). Individual differences in Children's Suggestibility: A review and synthesis. *Applied Cognitive Psychology, 18,* 947-996.

Buckner, R. L. & Schacter, D. L. (2004). Neural Correlates of Memory's Successes and Sins. In M. S. Gazzaniga (Ed in chief), *The Cognitive Neurosciences* (3rd ed., pp. 739-752). MA: MIT Press.

Buckner, R.L. & Wheeler, M.E. (2001). The cognitive neuroscience of remembering. *Nature Neuroscience, 2,* 624-634.

Buffalo, E. A., Ramus, S. J., Squire, L. R., & Zola, S. M. (2000). Perception and recognition memory in monkeys following lesions of area TE and perirhinal cortex. *Learning and Memory, 7,* 375-382.

Cabeza, R., Rao, S. M., Wagner, A. D., Mayer, A. R., & Schacter, D. L. (2001). Can medial temporal lobe regions distinguish true from false? An event-related functional MRI study of vertical and illusory recognition memory. *Proceedings of the National Academy of Sciences of the United States of America, 98,* 4805-4810.

Cattell, R. B. (1943). The description of personality: Basic traits resolved into clusters. *Journal of Abnormal and Social Psychology, 38,* 476-507.

Chung, G., Tucker, D. M., West, P., Potts, G. F., Liotti, M., Luu, P., & Hartry, A. L. (1996). Emotions expectancy: Brain electrical activity associated with an emotional bias in interpreting life events. *Psychophysiology, 33(3),* 218-233.

Cohen, J. & Polich, J. (1997). On the number of trials needed for P300. *International Journal of Psychophysiology, 25,* 249-255.

Corkin, S, Amaral, D. G., Gonzales, R. G., Johnson, K. A., & Hyman, B. T. (1997).

H. M.'s medial temporal lobe lesion: Findings from magnetic resonance imaging. *Journal of Neuroscience, 17,* 3964-3980.

Coolidge, F.L., Moor, J.C., Yamazaki, T.G., Stewart, S.E. and Segal, D.L., 2001. On the relationship between Karen Horney's tripartite neurotic type theory and personality disorders features. *Personality and Individual Differences, 30*, 1387–1400

Cooper, R., Osselton, J. W., & Shaw, J. C. (1980). *EEG Technology* (2nd ed.). Boston: Butterworth.

Costa, P. T. and McCrae, R. R. (1992). *Revised NEO Personality Inventory (NEO-PI-R) and NEO Five Factor Inventory (NEO-FFI) Professional Manual*. Odessa, FL: Psychological Assessment resources.

Courchesne, E., Hillyard, S. A., & Galambos, R. (1975). Stimulus novelty, task relevance and the visual evoked potential in man. *Electroencephalography and Clinical Neurophysiology, 39,* 131-143.

Craik, F. I. M., & Lockhart, S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior, 11,* 671-684.

Curran, T. (1999). The electrophysiology of incidental and intentional retrieval: ERP old/new effects in lexical decision and recognition memory. *Neuropsychologia, 37,* 771-785.

Curran, T. (2000). Brain potentials of recollection and familiarity. *Memory and Cognition, 28,* 923-938.

Curran, T. (2004). Effects of attention and confidence on the hypothesized ERP correlates of recollection and familiarity. *Neuropsychologia, 42,* 1088-1106.

Curran, T., & Cleary, A. M. (2003). Using ERPs to dissociate recollection from familiarity in picture recognition. *Cognitive Brain Research, 15,* 191-205.

Curran, T., & Dien, J. (2003). Differentiating amodal familiarity from modality-specific memory processes: An ERP study. *Psychophysiology, 40,* 979-988.

Curran, T., Schacter, D. L., Johnson, M. K., & Spinks, R. (2001). Brain potentials reflect behavioral differences in true and false recognition. *Journal of Cognitive Neuroscience, 13,* 201-216.

Curran, T., Schacter, K. A., Norman, L., &Galluccio, L. (1997). False recognition after a right frontal lobe infarction: memory for general and specific information, *Neuropsychologia, 35,* 1035-1049.

Deese, J. (1959). On the prediction of occurrence of particular verbal intrusions in immediate recall. *Journal of Experimental Psychology, 58,* 17-22.

Desimone, R., & Ungerleider, L. G. (1989). Neural mechanisms of visual processing in monkeys. In F. Boller & Grafman (Eds.). *Handbook of Neurophysiology,* 2, 267-299.

Destun, L. M. & Kuiper, N. A. (1996). Autobiographical memory and recovered memory therapy: Integrating cognitive, clinical, and individual difference perspectives. *Clinical Psychology Review, 16,* 421-450.

Donaldson, D. I., & Rugg, M. D. (1998). Recognition memory for new associations: electrophysiological evidence for the role of recollection. *Neuropsychologia, 36,* 377-395.

Donaldson, D. I., & Rugg, M. D. (1999). Event-related potential studies of associative recognition and recall. *Cognitive Brain Research, 8,* 1-16.

Donchin, E., & Coles, M. G. H. (1998). Context updating and the P300. *Behavioral and Brain Sciences, 21,* 149-168.

Duncan-Johnson, C. C., & Donchin, E. (1977). On quantifying surprise: The variation of event-related potentials with subjective probability. *Psychophysiology, 14,* 456-467.

Eisen, M. L., Morgan, D. Y., & Mickes, L. (2002). Individual differences in eyewitness memory and suggestibility: examining relations between acquiescence, dissociation and resistance to misleading information. *Personality and Individual Differences, 33,* 553-571.

Eldridge, L. L., Knowlton, B. J., Furmanski, C. S., Bookheimer, S. Y., & Engel, S. A. (2000). Remembering episodes: a selective role of the hippocampus during retrieval. *Nature Neuroscience, 3*, 1149-1152.

Eysenck, H. J., & Eysenck, S. B. J. (1975). *Manual of Eysenck Personality Questionnaire*. London: Hodder and Stoughton.

Eysenck, S.B.G., Eysenck, H.J., & Barrett, P. (1985). A revised version of the Psychoticism scale. *Personality and Individual Differences 6*, 21–29.

Eysenck, S. B. G., & Haraldson, E. (1983). National differences in personality: Iceland and England, *Psychological Reports, 53,* 999-1003.

Fabiani, M. & Friedman, D. (1995). Changes in brain activity patterns in aging: The novelty oddball. *Psychophysiology, 32,* 579-594.

Fabiani, M., Gratton, G., & Coles, M. (2000). Event-Related Potentials: Methods, Theory, and Applications. In Cacioppo, J. T., Tassinary, L. G., & Berntson, G. (Eds). *Hand book of psychophysiology* (2nd ed., pp. 53-84). Paris: Camridge University Press.

Feige, R. K., Rossi, S., Feige, B., Mergner, T., Lucking, C. H., & Rossini, P. M. (1997).

The bereitschaftspotential paradigm in investigating voluntary movement organization in humans using magnetoencephalography (MEG). *Brain Research Protocols, 1(1),* 13-22.

Fiske, D. W. (1949). Consistency of the factorial structures of personality ratings from different sources. *Journal of Abnormal and Social Psychology, 44,* 329-344.

Friedman, D., & Johnson, R., Jr. (2000). Event-related potential (ERP) studies of memory encoding and retrieval: a selective review. *Microscopy Research and Technique, 51,* 6-28.

Gabb, N., Keenan, J. P., & Schlaug, G. (2003). The effects of gender on the neural substrates of pitch memory. *Journal of Cognitive Neuroscience, 15(6),* 810-820.

Gardiner, J. M., & Java, R. J. (1991). Forgetting in recognition memory with and without recollective experience. *Memory and Cognition, 19,* 617-623.

Garry, M., Manning, C. G., Loftus, E. F., & Sherman, S. J. (1996). Imagination inflation: Imagining a childhood event inflates confidence that it occurred. *Psychonomic Bulletin and Review, 3,* 208-214.

Gehring, W. J., Gratton, G., Coles, M. G., & Donchin, E. (1992). Probability effects on stimulus evaluation and response processes. *Journal of Experimental Psychology: Human Perception and Performance, 18,* 198-216.

Gerrie, M.P., Garry, M., & Loftus, E.F. (2004). False Memories. In N. Brewer & K. Williams (Eds.). *Psychology of Law: An Empirical Perspective*. New York: Guilford Press (in press).

Goldberg, L. R. (1990). An alternative “description of personality”: The big-five factor structure. *Journal of Personality and Social Psychology, 59,* 1216-1229.

Goldberg, L. R. (1992). The development of markers of the Big Five factor structure. *Psychological assessment, 4,* 26-42.

Gonsalves, B., & Paller, K. A. (2000). Neural events that underlie remembering something that never happened. *Nature Neuroscience, 3,* 1316-1321.

Gratton, G., Coles, M. G. H. & Donchin E. (1983). A new method for the off-line removal of ocular artifact. *Electroencephalography & Clinical Neurophysiology, 55,* 468-484.

Gudjonsson, G. H. (1983). Suggestibilty, intelligence, memory recall and personality: an experimental study. *British Journal of Psychiatry, 142,* 35-37.

Gudjonsson, G. H. (1987a). Historical background to suggestibility: How interrogative suggestibility differs from other types of suggestibility. *Personality and Individual Differences, 8(3),* 347-355.

Gudjonsson, G. H. (1987b). The Relationship between memory and suggestibility. *Social Behaviour, 2,* 29-33.

Gudjonsson, G. H. (1988a). The relationship of intelligence and memory to interrogative suggestibility: the importance of range effects. *British Journal of Clinical Psychology, 27,* 185-187.

Gudjonsson, G. H. (1988b). Interrogative Suggestibilty: its relationship with assertiveness, social-evaluative anxiety, state anxiety and method of coping. *British Journal of Clinical Psychology, 27,* 159-166.

Gudjonsson, G. H. (1989). Compliance in an interrogation situation: A new scale. *Personality and Individual Differences, 10,* 535-540.

Gudjonsson, G. H. (1997). *The Gudjonsson Suggestibility Scales Manual*. East Sussex, UK: Psychology Press.

Gudjonsson, G. H. (2003). *The Psychology of Interrogations and Confessions.* West Sussex: John Wileys & Sons.

Gudjonsson, G. H. & Clare, I. C. H. (1995). The relationship between confabulation and intellectual ability, memory, interrogative suggestibility and acquiescence. *Personality and Individual Differences, 19,* 333-338.

Gudjonsson, G. H. & Clark, N. K. (1986). Suggestibility in police interrogation: a social psychological model. *Social Behaviour, 1,* 83-104.

Gudjonsson, G. H. & Petursson, H. (1991).Custodial interrogation: why do suspects confess and how does it relate to their crime, attitude and personality? *Personality and Individual Differences, 12,* 295-306.

Gudjonsson, G. H., Rutter, S. C., & Clare, I. C. H. (1995). The relationship between suggestibility and anxiety among suspects detained at police stations. *Psychological Medicine, 25,* 875-878.

Gudjonssons, G. H. & Sigurdsson, J. F. (1994). How frequently do false confessions occur? *Psychology Crime and Law, 1(1)*, 21-26.

Gudjonsson, G. H. & Sigurdsson, J. F. (1999). The Gudjonsson Confession Questionnaire-Revised (GCQ-R): factor structure and its relationship with personality. *Personality and Individual Differences, 27(5),* 953-968.

Gudjonsson, G. H. & Singh, K. K. (1984). Interrogative suggestibility and delinquent boys: an empirical validation study. *Personality and Individual Differences, 5,* 425-430.

Guillem, F. & Mograss, M. (2005). Gender differences in memory processing: Evidence from event-related potentials to faces. *Brain and Cognition, 57,* 84-92.

Haberlandt, K. (1999). *Human Memory: Exploration and Application.* Boston: Allyn & Bacon.

Halgren, E., Squires, N. K., Wilson, C. L., Rohrbaugh, J. W., Babb, T. L., & Randall, P. H. (1980). Endogenous potentials generated in the human hippocampal formation and amygdala by infrequent events. *Science, 210*, 803-805.

Haraldson, E. (1985). Interrogative Suggestibility and its relationship with personality, perceptual defensiveness and extraordinary beliefs. *Personality and Individual Differences, 5,* 765-767.

Harter, M. R., & Aine, C. J. (1984). Brain Mechanisms of visual selective attention. In R. Parasuraman & R. Davies (Eds.). *Varieties of Attention* (pp. 293-321). London: Academic Press.

Harter, M. R., Aine, C., & Schroeder, C. (1982). Hemispheric differences in the neural processing of stimulus location andtype: Effects of selective attention on visual evoked potentials. *Neuropsychologia, 20,* 421-436.

Heinze, H. J., Luck, S. J., Mangun, G. R., & Hillyard, S. A. (1990). Lateralized visual ERPs index focused attention to bilateral stimulus arrays: Evidence for early selection. *Electroencephalography and Clinical Neurophysiology, 75,* 511-527.

Heinze, H. J., Magnum, G. R., Burchert, W., Hinrichs, H., Scholz, M., Munte, T. F., Gos, A., Scherg, M., Johannes, S., Handeshagen, H., Gazzaniga, M. S., Hillyard, S. A.: Combined spatial and temporal imaging of brain activity during visual selective attention in humans. (1994). *Nature, 372(6506),* 543-546.

Henson, R. N., Rugg, M. D., Shallice, T., & Dolan, R. J. (2000). Confidence in recognition memory for words: Dissociating right prefrontal roles in episodic retrieval. *Journal of Cognitive Neuroscience, 12,* 913-923.

Henson, R. N. A., Rugg, M. D., Shallice, T., Josephs, O., & Dolan, R. J. (1999). Recollection and familiarity in recognition memory: an event-related functional magnetic resonance imaging study. *Journal of Neuroscience, 19,* 3962-3972.

Henson, R. N., Shallice, T., & Dolan, R. J. (1999). Right prefrontal cortex and episodic memory retrieval: A functional MRI test of the monitoring hypothesis. *Brain, 122,* 1367-1381.

Hintzman, D. L., & Curran, T. (1994). Retrieval dynamics of recognition and frequency judgments: evidence for separate processes of familiarity and recall. *Journal of Memory And Language, 33,* 1-18.

Hockley, W. A., & Consoli, A. (1999). Familiarity and recollection in item and associative recognition. *Memory and Cognition, 27,* 657-664.

Hook, C. W. V. & Steele, C. (2002). Individual personality characteristics related to suggestibility. *Psychological Reports, 91(3, pt1),* 1007-1010.

Hopfinger, J. B., Luck, S. J., & Hillyard, S. A. (2004). Selective Attention: Electrophysiological and Neuromagnetic Studies. In M. S. Gazzaniga (Ed in chief), *The Cognitive Neurosciences* (3rd ed., pp. 561-574). MA: MIT Press.

Howard, R. C. (2001). Bringing Brain Events to Mind: Functional Systems and Brain Event-Related Potentials. *Journal of Psychophysiology, 15(2),* 69-79.

Howard, R.C. & Goh, J. A (2002). Brain Event-Related Potential (ERP) Correlate of Individual Differences in Interrogative Suggestibility (IS). [On-Line]. Abstract from: http://psy.otago.ac.nz/awcbr/Abstracts2002.htm#Howard

Howard, R.C. and Ng, S. H. (2002) Effects of coping style on interrogative suggestibility. *Personality & Individual Differences, 33(3),* 479-485.

Jacoby, L. L. (1991). A process dissociation framework: separating automatic from intentional uses of memory. *Journal of memory And Language, 30,* 513-541.

Jacoby, L. L., & Dallas, M. (1981). On the relationship between autobiographical memory and perceptual learning. *Journal of Experimental Psychology: Learning, Memory and Cognition, 9,* 21-38.

James, W. (1890). *The principles of psychology*. New York: Holt.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin, 114,* 3-28.

Johnson, R., Jr. (1993). On the neural generators of the P300 component of the event-related potential. *Psychophysiology, 30,* 90-97.

Johnson, R., Jr. (1995). Event-related potential insights into the neurobiology of memory Systems. In F. Boller, & J. Grafman (Eds.), *Handbook of Neuropsychology, 10,* 135-163.

Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice-Hall.

Kassin, S. M. & Wrightsman, L. S. (1985). Confession evidence. In S. M. Kassin and L. S. Wrightsman (Eds.).The Psychology of evidence and trial procedures. London: Sage, 67-94.

Kiehl, K., Smith, A.M., Hare, R.D. and Liddle, P.F. (2000). An event-related potential investigation of response inhibition in schizophrenia and psychopathy. *Biological Psychiatry*, 48, 210-221.

Knowlton, B. J., & Squire, L. R. (1995). Remembering and knowing: Two different expressions of declarative memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21,* 699-710.

Kutas, M., & Hillyard, S. A. (1980). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science, 207,* 203-205.

Kutas, M., McCarthy, G., & Donchin, E. (1977). Augmenting mental chronometry: The P300 as a measure of stimulus evaluation time. *Science, 197,* 792-795.

Kutas, M., & Petten, V. (1994). Psycholinguistics electrified: event-related brain potential Investigations. In: M. Gernsbacher (Ed.), *Handbook of Psycholoinguistics* (pp. 83-143). NY: Academic Press.

Larsen, R. J., & Buss, D. M. (2002). *Personality Psychology: Domains of Knowledge About Human Nature.* McGraw-Hill: NY.

Lee, K. (2004). Age, neuropsychological, and social cognitive measures as predictors of individual differences in susceptibility to the misinformation effect. *Applied Cognitive Psychology, 18,* 997-1019.

Liebman, J. I., Mc-Kinley-Pace, M., Leonard, A. M., Sheesley, L.A. Gallant, C. L., Renkey, M, E., & Lehman, E. B. (2002). Cognitive and psychosocial correlates of adults' eyewitness accuracy and suggestibility. *Personality and Individual Differences,33,* 49-66.

Lindberg, M. (1991). A taxonomy of suggestibility and eyewitness memory: age, memory, process, and focus of analysis. In J. Doris (Ed.), *The suggestibility of children's recollection: implications for eyewitness memory* (pp. 47-55). Washington, DC: American Psychological Association, Lindin, M., Zurron, M., & Diaz, F. (2004). Changes in P300 amplitude during an active standard auditory oddball task. *Biological Psychology, 66,* 153-167.

Loftus, E. F. (1979). *Eyewitness testimony*. London: Harvard University Press.

Loftus, E. F., Miller, D. G., & Burns, H. J. (1978). Semantic integration of verbal information. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 27, pp. 187-215). San Diego, CA: Academic Press.

Lowe, P. A., Mayfield, J. W., & Reynolds, C. R. (2003). Gender differences in memory test performance among children and adolescents. *Archives of Clinical Neuropsychology, 18,* 865-878.

Mandler, G. (1980). Recognizing: the judgment of previous occurrence. *Psychological Review, 87,* 252-271.

Mandler, G. (1991). Your face looks familiar but I can't remember your name: a review of dual process theory. In W. Hockley, & S. Lewandowski (Eds.), *Relating Theory and Data: Essays on Human Memory in Honor of Bennet B. Murdock* (pp. 207-225). NJ: Erlbaum, Hillsdale.

Mangun, G. R., & Hillyard, S. A. (1990). Electrophysiological studies of visual selective attention in humans. In A. Scheibel & A. Wechsler (Eds.), *The Neurobiological Foundations of Higher Cognitive Function* (pp. 271-294). New York: Guilford.

Mangun, G. R., & Hillyard, S. A. (1995). Mechanisms and models of selective attention. In Rugg, M. D., & Coles, M. G. H. (Eds.), *Electrophysiology of Mind* (pp. 40-85). New York: Oxford University Press.

Manns, J. R., & Squire, L. R. (1999). Impaired recognition memory on the Doors and People Test after damage limited to the hippocampal region. *Hippocampus, 9,* 485-499.

Marche, T. A. (1999). Memory strength affects reporting if misinformation. *Journal of Experimental Child Psychology, 73,* 45.

Marche, T. A., & Howe, M. L. (1995). Preschoolers report misinformation despite accurate memory. *Developmental Psychology, 31,* 554-567.

Pezdek, K., & Roe, C. (1995). The effect of memory trace strength on suggestibility. *Journal of Experimental Child Psychology, 60,* 116-128.

McDonald, A. P. (1970). Revised scale for ambiguity tolerance: reliability and validity. *Psychological Reports, 26,* 791-798.

Mecklinger, A. (2000). Interfacing mind and brain: a neurocognitive model of recognition memory. *Psychophysiology, 37*, 565-582.

Milgram, S. (1974). *Obedience to authority.* London: Tavistock Publications.

Millon, T. (1994). *Millon Index of Personality Styles*. San Antonio, TX: Psychological Corp.

Moscovitch, M. (1992). A neuropsychological model of memory consciousness. In L. R. Squire & N. Butters (Eds.), *Neuropsychology of Memory* (2^{nd} ed., pp. 5-22). New York: Guilford Press.

Moscovitch, M., Vrizen, E., & Gottstein, J. (1993). Implicit tests of memory in patients with focal lesions or degenerative brain disorders. In F. Boller, & J. Grafman. (Eds.). *Hand book of psychophysiology, 8,* 133-173.

Muris, P., Meester, C., & Merckelbach (2004). Correlates of the Gudjonsson Suggestibility Scales in delinquent adolescents. *Psychological Reports, 94(1),* 264-266.

Naatanen, R. (1992). *Attention and Brain Function.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Naatanen, R., & Alho, K. (1995). Event-related potentials in selective attention research. In R. Johnson, Jr., & J.C. Baron (Eds.). *Handbook of Neuropsychology, 10,* 75-104.

Naatanen, R., &, Gaillard, A. W. K. (1983). The N2 deflection of ERP and the orienting reflex. In A. W. K. Gaillard, & W. Ritter (Eds.). *EEG correlates of information processing: Theoretical issues* (pp. 119-141). Amsterdam: North Holland.

Nessler, D., Mecklinger, A., & Penney, T. B. (2001). Event related brain potentials and illusory memories: the effects of differential encoding. *Cognitive Brain Research, 10,* 283-301.

Norman, W. T. (1963). Toward an adequate taxanomy of personality attributes: Replicated factor structure in peer nomination personality ratings. *Journal of Abnormal Psychology, 66,* 574-583.

Okado, Y., & Clark, C. E. L. (2004). Neural activity during encoding predicts false memories created by misinformation. *Learning and Memory, 12,* 3-11.

Paller, K. A. (1990). Recall and stem-completion priming have different electrophysiological correlates and are modified differentially by directed forgetting. *Journal of Experimental Psychology: Learning, Memory, Cognition: 16,* 1021-1032.

Paller, K. (2002). Cross-Cortical Consolidation as the Core Defect in Amnesia. In L. R. Squire, & D. L. Schacter (Eds.), *Neuropsychology of Memory* (3rd ed., pp. 114-129). New York: Guilford Press.

Paller, K. A., & Kutas, M. (1992). Brain potentials during memory retrieval provide neurophysiological support of the distinction between conscious recollection and priming. *Journal of Cognitive Neuroscience, 4,* 375-391.

Paller, K. A., Kutas, M., & Mayes, A. R. (1987). Neural correlates of encoding in an incidental learning paradigm. *Electroencephalography and Clinical Neurophysiology, 67,* 360-371.

Pavlov, I. P. (1927). *Conditioned reflexes*. Oxford: Clarendon Press.

Pezdek, K. & Roe, C. (1995). The effect of memory trace strength on suggestibility. *Journal of Experimental Child Psychology, 60,* 116-128.

Polczyk, R. (2005). Interrogative suggestibility: cross-cultural stability of psychometric and correlational properties of the Gudjonsson Suggestibility Scales. *Personality and Individual Differences, 38,* 177-186.

Powers, P. A., Andriks, J. L., & Loftus, E. F. (1979). Eyewitness account of females and males. *Journal of Applied Psychology, 64,* 339-347.

Pritchard, W. S. (1981). Psychophysiology of P300. *Psychological Bulletin, 89(3),* 506-540.

Raaijmakers, J. G. W., & Shiffrin, R. M. (1992). Models for recall and recognition. *Annual Review of Psychology, 43,* 205-234.

Ratcliff, R., & McKoon, G. (2000). Memory models. In E. Tulving, & F.I.M. Craik (Eds.), *The Oxford Handbook of Memory* (pp.571-581). New York: Oxford University Press.

Rempell-Clower, N. L., Zola, S. M., Squire, L. R., & Amaral, D. G. (1996). Three cases of enduring memory impairment following bilateral damage limited to the hippocampal formation. *Journal of Neuroscience, 16,* 5233-5255.

Ritter, W., Simson, R., & Vaughan, H. G., jun. (1983). Event-related potential correlates of two stages of information processing in physical and semantic discrimination tasks. *Psychophysiology, 20,* 168-179.

Roediger, H. L., & McDermott, K. B. (1993). Implicit memory in normal human subjects. In H. Spinnler, & J. Boller (Eds.). *Handbook of Neuropsychology, 9,* 63-131.

Roediger, H. L. I., & McDermott, K. B. (1995). Creating false memories: remembering words not presented in lists. *Journal of Experimental Psychology: Learning, Memory and Cognition, 21(4),* 803-814.

Rugg, M. D. (1995). ERP studies of memory. In M.D.Rugg, & M. G. H. Coles (Eds.), *Electrophysiology of Mind* (pp. 132-170). New York: Oxford University Press.

Rugg, M. D. (2004). Retrieval processing in human memory: Electrophysiological and fMRI evidence. In M. S.Gazzaniga (Ed.), The Cognitive Neurosciences (3rd ed., pp. 727-737). Cambridge, MA : MIT press.

Rugg, M. D., & Allan, K. (2000). Event-related potential studies of memory. In E. Tulving, & F. I. M. Craik (Eds.), *The Oxford Handbook of Memory* (pp. 521-537). New York: Oxford University Press.

Rugg, M. D., & Doyle, M. C. (1992). Event-related potentials and and recognition memory for low and high frequency words. *Journal of Cognitive Neuroscience, 4,* 69-79.

Rugg, M. D., Mark, R. E., Walla, P., Schloerscheidt, A. M., Birch, C. S., & Allan, K. (1998). Dissociation of the neural correlates of implicit and explicit memory. *Nature, 392,* 595-598.

Sanquist, T. F., Rohrbaugh, J. W., Syndulko, K., & Lindsey, D. B. (1980). Electrocortical signs of levels of processing: Perceptual analysis and recognition memory. *Psychophysiology, 17,* 568-576.

Schacter, D. L. (1999). The seven sins of memory: insights from psychology and cognitive neurosciences. *American Psychologist, 54,* 182-203.

Schacter, D. L., Kagan, J., Leichtman, M. D. (1995). True and false memories in children and adults: A cognitive neuroscience perspective. *Psychology, Public Policy, and Law, 1(2),* 411-428.

Schacter, D. L., Norman, K. A., & Koutstaal, W. (1998). The cognitive neuroscience of constructive memory. *Annual Review of Psychology, 49*, 289-318.

Schacter, D. L., & Tulving, E. (Eds.). (1994). *Memory systems 1994*. Cambridge, MA: MIT Press.

Schacter, D. L., Verfaellie, M., & Anes, M. D. (1997). Illusory memories in amnesic patients : Conceptual and perceptual false recognition. *Neuropsychology, 11,* 331-342.

Schacter, D. L., Verfaellie, M., & Koutstaal, W. (2002). Memory Illusions in Amnesic Patients. In L. R. Squire, & D. L. Schacter (Eds.), *Neuropsychology of Memory* (3rd ed., pp. 114-129). New York: Guilford Press.

Schacter, D. L., Verfaellie, M., & Pradere, D. (1996). The neuropsychology of memory illusions: False recall and recognition in amnesic patients. *Journal of Memory and Language, 35*, 319-334.

Schacter, D. L., & Wagner, A. D. (1999). Medial temporal lobe activation in fMRI and PET studies of episodic encoding and retrieval. *Hippocampus, 9,* 7-24.

Schooler, J. W., & Loftus, E. F. (1986). Individual differences and experimentation: complementary approaches to interrogative suggestibility. *Social behaviour,* 1, 105-112.

Scoville, W. B., & Milner, B. (1957). Loss of recent memory after bilateral hippocampal lesions. *Journal of Neurology, Neurosurgery and Psychiatry, 20,* 11-21.

Shatz, S. M. (2004). The relationship between Horney's three neurotic types and Eysenck's PEN model of personality. *Personality and Individual Differences, 37(6),* 1255-1261.

Sigurdsson, J. F. & Gudjonsson, G. H. (1996). Psychological characteristics of "false confessors": a study among Icelandic prison inmates and juvenile offenders. *Personality and Individual Differences, 20,* 321-329.

Smith, M. E. (1993). Neurophysiological manifestations of recollective experience during recognition memory judgments. *Journal of Cognitive Neurosciences, 5,* 1-13.

Smith, P., & Gudjonsson, G. H. (1995). Confabulation among forensic inpatients and its relationship with memory, suggestibility, compliance, anxiety, and self-esteem. *Personality and Individual Differences, 9(4),* 517-523.

Sokolov, E.N. (1963). Higher nervous functions: The orienting reflex. *Annual Review of Physiology, 25,* 545-580.

Speck, O., Ernst, T, Braun, J, Koch, C., Miller, E. & Chang, L. (2000). Gender differences in the functional organization of the brain for working memory. *Neuroreport***.** *11,* 2581-2585.

Spencer, K. M., Vila Abad, E., & Donchin, E. (2000). On the search for the neurophysiological manifestation of recollective experience. *Psychophysiology, 37,* 494-506.

Squire, L. R. (1992). Memory and the hippocampus: A synthesis from findings with rats, monkeys, and humans. *Psychological Review, 99,* 195-231.

Squire, L. R., & Zola-Morgan, S. (1991). The medial temporal lobe memory system. *Science, 253,* 1380-1386.

Stark, C. E. L. & Squire, L. R. (2000a). Recognition memory and familiarity judgments in severe amnesia: No evidence for a contribution of repetition priming. Behavioral *Neuroscience, 114,* 459-467.

Stark, C. E. L., & Squire, L. R. (2000b). Intact visual perceptual discrimination in humans in the absence of perirhinal cortex. *Learning and Memory, 7,* 273-278.

Stern, W. (1910). Abstracts of lectures on the psychology of testimony and on the study of individuality. *American Journal of Psychology, 21,* 273-282.

Stuss, D. T., Eskes, G. A., & Foster, J. K. (1994). Experimental neuropsychological studies of frontal lobe functions. In J. C. Boller, & J. Grafman. (Eds.). *Handbook of Neuropsychology, 9,* 149-183.

Tabachnick, B. G. & Fidell, L. S. (2001). *Computer-Assisted Research Design and Analysis.* MA: Allyn & Bacon.

Tousignant, J. P., Hall, D., & Loftus, E. F. (1986). Discrepancy detection and vulnerability to misleading post event information. *Memory and Cognition, 14,* 329-338.

Trenerry, M. R., Jack, C. R., Cascino, G. D., Sharbrough, F. W. & Ivnik, R. J. (1995). Gender differences in post-temporal lobectomy verbal memory and relationships between MRI hippocampal volumes and preoperative verbal memory. *Epilepsy Research, 20,* 69-76.

Trott, C. T., Friedman, D., Ritter, W., & Fabiani, M. (1997). Item and source memory: differential age effects revealed by event-related potentials. *Neuroreport, 8,* 3373-3378.

Trott, C. T., Friedman, D., Ritter, W., Fabiani, M., & Snodgrass, J. G. (1999). Episodic priming and memory for temporal source: Event-related potentials reveal age-related differences in prefrontal functioning. *Psychology and Aging 14 (3),* 390-413.

Tulving, E. (1984). Elements of Episodic memory. *Behavioral and Brain Sciences, 7,* 257-268.

Tulving, E. (1985). Memory and consciousness. *Canadian Psychology, 26,* 1-12.

Tulving, E., & Schacter, D. L. (1990). Priming and human memory systems. *Science, 247,* 301-306.

Verfaellie, M., & Cermak, L. S. (1999). Perceptual fluency as a cue for recognition judgments in amnesia. *Neuropsychology, 13,* 198-205.

Wagner, A. D., Stebbins, G. T., Masciari, F., Fleischman, D. A., & Gabrieli, J. D. (1998). Neurophysiological dissociation between recognition familiarity and perceptual priming in visual long-term memory. *Cortex, 34,* 493-511.

Walter, W. G., Cooper, R., Aldridge, V. J., McCallum, W.C., & Winter, A. L. (1964). Contingent negative variation: an electrical sign of sensory-motor association and expectancy in the human brain. *Nature 203,* 380–384.

WESP manual (2002) [available on-line]. University of Amsterdam,

http://www2.fmg.uva.nl/ozi_psychologie/html_manual/WESP_man_tot.htm

Wijers, A. A., Okita, T., Mulder, G., Mulder, L. J. M., Lorist, M. M., Poiesz, R., & Scheffers, K. M. (1987). Visual search and spatial attention: ERPs in focused and divided attention conditions. *Biological Psychology, 25,* 33-60.

Wilding, E. L. (1999). Separating retrieval strategies from retrieval success: An event-related potential study of source memory. *Neuropsychologia, 37,* 441-454.

Wilding, E. L., Rugg, M. D. (1996). An event-related potential study of recognition memory with and without retrieval of source. *Brain, 119,* 889-906.

Wilding, E. L., Rugg, M. D. (1997a). Event-related potential and the recognition memory exclusion task. *Neuropsychologia, 35,* 119-128.

Wilding, E. L., Rugg, M. D. (1997b). An event-related potential study of recognition memory for words spoken aloud or heard. *Neuropsychologia, 35,* 1185-1195.

Wilding, E. L., Doyle, M. C., & Rugg, M. D. (1995). Recognition memory with and without retrieval of context: an event-related potential study. *Neuropsychologia, 33,* 743-767.

Wright, D. B. & Stroud, J. N. (1998). Memory quality and misinformation for peripheral and central objects. *Legal and Criminological Psychology, 3,* 273-286.

Yonelinas, A. P. (2001). Conscious, Control, and confidence: the 3Cs of recognition memory. *Journal of Experimental Psychology: General, 130,* 361-379.

Yonelinas, A. P. (2002). Components of episodic memory: the contribution of recollection and familiarity. In A. Baddeley, J. P. Aggleton, & M. A. Conway (Eds.), *Episodic Memory: New Directions in Research* (pp.31-52). NY: Oxford University Press.

Yonelinas, A. P., Kroll, N. E. A., Dobbins, I., Lazzara, M., & Knight, R. T. (1998). Recollection and familiarity deficits in amnesia: Convergence of remember-know, process dissociation, and receiver operating characteristic data. *Neuropsychology, 12,* 323-339.

Zuckerman, M. & Lubin, B. (1965). *Manual for the Multiple Affect Adjective Checklist*. Palo Alto, CA: Consulting Psychologists.

Appendix A

GSS1 story

Anna Thomson/ of South/ Croydon/ was on holiday/ in Spain/ when she was held up/ outside her hotel/ and robbed of her handbag/ which contained £50 worth/ of travelers cheques/ and her passport./ She screamed for help/ and attempted to put up a fight/ by kicking one of the assailants/ in the shins./ A police car shortly arrived/ and the woman was taken to the nearest police station/ where she was interviewed by Detective/ Sergeant/ Delgado./ The woman reported that she had been attacked by three men/ one of whom she described as orienting looking./ The men were said to be slim/ and in their early twenties./ The police officer was touched by the woman's story/ and advised her to contact the British Embassy./ Six days later/ the police recovered the woman's handbag/ but the contents were never found./ Three men were subsequently charged/ two of whom were convicted/ and given prison sentences./ Only one/ had previous convictions/ for similar offences./ The woman returned to Britain/ with her husband/ Simon/ and two friends/ but remained frightened of being out on her own./

GSS1 questions

1. *Did the woman have a husband called Simon?*
2. Did the woman have one or two children?
3. Did the woman's glasses break in the struggle?
4. Was the woman's name Anna Wilkinson?
5. *Was the woman interviewed by a detective sergeant?*
6. Were the assailants black or white?
7. Was the woman taken to the central police station?
8. Did the woman's handbag get damaged in the struggle?
9. *Was the woman on holiday in Spain?*
10. Were the assailants convicted six weeks after their arrest?
11. Did the woman's husband support her during the police interview?
12. Did the woman hit one of the assailants with her fist or handbag?
13. *Was the woman from South Croydon?*
14. Did one of the assailants shout at the woman?
15. Were the assailants tall or short?
16. Did the woman's screams frighten the assailants?
17. *Was the police officer's name Delgado?*
18. Did the police give the woman a lift back to her hotel?
19. Were the assailants armed with knives?
20. Did the woman's clothes get torn in struggle?

Items no. 1, 5, 9, 13, and 17 are factual questions which are counted for shift scores in case that participants change their answers.

GSS2 story

Anna and John/ were a happily married couple/ in their thirties./ They had three children,/ two boys/ and a girl./ They lived in a small bungalow/ which had a swimming pool/ in the garden./ John worked in a bank/ and Anna worked in a bookshop/ with her sister/ Maria./ One Tuesday/ morning/ in July/ the couple were leaving the house/ to go to work/ when they saw a small boy/ going down a steep slope/ on a bicycle/ and calling for help./ Anna and John ran after the boy/ and John caught hold of the bicycle/ and brought it to a halt./ The boy appeared very frightened/ but unhurt/ and said that the brakes on his bicycle had broken./ Anna and John recognized the boy,/ whose name was William./ He was the youngest/ son of their neighbours/ who worked for a well-known/ travel agency/ in a nearby town./ Sometimes in the winter months/ the two couples had gone skiing together/ but the children of both families/ had preferred to stay with their grandparents/ who lived in the country./

GSS2 questions

1. *Were the couple called Anna and John?*
2. Did the couple have a dog or a cat?
3. Did the boy's bicycle get damaged when it fell on the ground?
4. Was the husband a bank director?
5. *Did the couple live in a small bungalow?*
6. Did the boy on the bicycle pass a stop sign or traffic lights?
7. Was the boy frightened of the big van coming up the hill?
8. Did the boy have some minor bruises as a result of the accident?
9. *Was the boy's name William?*
10. Did the boy drop the books he had been carrying whilst riding the bicycle?
11. Was Anna worried that the boy might be injured?
12. Did John grab the boy's arm or shoulder?
13. *Did the couple recognize the boy?*
14. Did the boy commonly ride the bicycle to school?
15. Was the boy taken home by Anna or John?
16. Was the boy allowed to stay away from school on the day of accident?
17. *Did the couple's children sometimes stay with their grandparents?*
18. Was the boy frightened of riding the bicycle again?
19. Was the weather wet or dry when the accident happened?
20. Did the couple have a skiing cottage in the mountains?

Items no. 1, 5, 9, 13, and 17 are factual questions which are counted for shift scores in case that participants change their answers.

Appendix B

The GCS (Form D)

Listed below are a number of statements concerning personal attitudes and traits. Read each item and decide whether the statement is *true* **or** *false* **as it applies to you personally. If the statement is true as applied to you then circle "T"; if it is false as applied to you then circle "F"**

1. As a child, I always did as my parents told me.
2. I give in easily when I am pressured.
3. I am not too concerned what people think of me.
4. I tend to become easily alarmed and frightened when in the company of people in authority.
5. When I was a child I sometimes took the blame for things I had not done.
6. When I am uncertain about things I tend to accept what people tell me.
7. I tend to go along with what people tell me even when I know that they are wrong.
8. I would describe myself as a very obedient person.
9. I would never go along with what people tell me in order to please them.
10. I find it very difficult to tell people when I disagree with them.
11. I tend to give in to people who insist that they are right.
12. I try very hard not to offend people in authority.
13. I strongly resist being pressured to do things I don't want to.
14. I generally tend to avoid confrontation with people.
15. I try to please others.
16. People in authority make me feel uncomfortable and uneasy.
17. I try hard to do what is expected of me.
18. Disagreeing with people often takes more time than it is worth.
19. I generally believe in doing as I am told.
20. I believe in avoiding rather than facing demanding situations.

Appendix C: PEMQ

1. What sex was the experimenter you met with last week? __________
2. What was the experimenter's name? ____________________
3. How tall was that person? ____________________
4. What was that person wearing? ____________________
5. What time of day was it when you participated in the experiment?__________
6. How long did the experimental procedures take that day?_____________
7. Was there a radio in that room? ________________
8. There was something moving around on the computer screen while you were sitting at the desk in that room. What was it? _____________________
9. Were there bookshelves in that room? ___________
10. Is there a file cabinet in there? ___________
11. Were there two computers in that room? __________
12. She didn't actually ask you to write anything down, did she?___________
13. There isn't a phone in that room, is there? _______________
14. Were you asked to read anything? ______________
15. There were no books on the shelves, were there?______________
16. They only keep red pens in that office. I hate those red pens. You had to use one, didn't you? ___________________
17. Were you asked to remember a list of words related to fruit?__________
18. That list with the dirty words on it always gets a laugh. In reviewing your work I recall that you did well on that list, right? ______________
19. Were the bookshelves empty? ________________
20. She asked you to read from a book, right? (If yes: what did she ask you to read, from the book? If no: oh, I was going to ask you what it was?)__________
21. What colour were the walls in that room? __________
22. Someone knocked on the door to interrupt, didn't they? ___________
23. What was the weather like at NUS during the time that you participated in the experiment? _________________________
24. We used to have some real cool pictures in there. There aren't any pictures in that room, are there? __________________________
25. What colour were the chairs in that room? ____________________
26. I heard a second person came in the room for just a second while you were there. That happens a lot. Was it a man or a woman that came in to the room?_________
27. What color was the experimenter's shirt?____________________
28. There was no clock in that room, was there? ______________
29. They always leave that radio on and it bothers the students who come here for the research. The experimenter turned the music off right after you came in the room, didn't she? ____________________
30. There's only one desk in that room, right? _______________
31. Was there a fan in the room? ______________
32. There aren't any trashcans in that room, are there? ______________
33. Were the windows all closed? ______________
34. Were there books in that room? ________________
35. There are only two chairs in that room, aren't there? _____________

36. Did the experimenter use a clipboard? _______________
37. The experimenter had a stopwatch around his/her neck, right? ____________
38. Was there a mirror in the room? _______________
39. There's a pencil sharpener on the wall in that room, isn't there?____________
40. Did the experimenter leave the room during any of the procedure?___________
41. There's no lamp in that room, is there? _____________
42. She didn't have you signed anything, didn't she? _____________
43. Did the experimenter ask you to draw anything?__________________
44. There were no flowers in the room, were there? _______________
45. Was the experimenter wearing a red shirt? __________________
46. There were no stuffed animals or toys in the room, were there? ____________
47. Did the experimenter tell you to try to remember everything that occurred because we would test your memory the following week? _____________
48. You were asked to remember lists of numbers, weren't you? (If no: "oh, I was going to ask you what they were! If yes: what were they?").________________
49. Did the experimenter tell you to try not to think of a pink elephant?________
50. The experimenter never actually shook your hand, did she?_______________
51. Did the experimenter ask you to remember anything for this week?_________
52. There was no mirror in the room, was there? _____________
53. Did the experimenter stay in the room the entire time while you were here last week?_________________
54. Were any of the windows open? __________________
55. The computer in that room is always freezing up. Did it freeze up while you were there? ______________________
56. Were there any pictures on the wall? ____________________
57. Did the experimenter ask you to read from a book? __________________

The PEMQ has five categories of questions; namely, 11 open questions (item no. 1-6, 8, 21, 23, 25, 27), 20 specific questions (keyed to yes = 9 items, no. 7, 9, 14, 17, 30, 33, 36, 38, 40; keyed to no = 11 items, no. 10, 11, 31, 43, 45, 47, 49, 51, 54, 55, 57), four repeated (specific) questions which were labeled Repeated question in the result tables (item no. 19, 34, 53, 56), 22 misleading questions (keyed to no = 9 items, no. 16, 18, 22, 26, 29, 35, 37, 39, 48; keyed to yes = 13 items, no.12, 13, 15, 20, 24, 28, 32, 41, 42, 44, 46, 50, 52), items no. 20, 52 of misleading questions also categorized as repeated misleading questions.

Appendix D

DRM word lists (Roediger & McDermott, 1995)

List 1	List 2	List 3	List 4	List 5	List 6	List 7	List 8
ANGER	**BLACK**	**BREAD**	**CHAIR**	**COLD**	**DOCTOR**	**FOOT**	**FRUIT**
Mad	White	Butter	Table	Hot	Nurse	Shoe	Apple
Fear	Dark	Food	Sit	Snow	Sick	Hand	Vegetable
Hate	Cat	Eat	Legs	Warm	Lawyer	Toe	Orange
Rage	Charred	Sandwich	Seat	Winter	Medicine	Kick	Kiwi
Temper	Night	Rye	Cough	Ice	Health	Sandals	Citrus
Fury	Funeral	Jam	Desk	Wet	Hospital	Soccer	Ripe
Ire	Color	Milk	Recliner	Frigid	Dentist	Yard	Pear
Wrath	Grief	Flour	Sofa	Chilly	Physician	Walk	Banana
Happy	Blue	Jelly	Wood	Heat	Ill	Ankle	Berry
Fight	Death	Dough	Cushion	Weather	Patient	Arm	Cherry
Hatred	Ink	Crust	Swivel	Freeze	Office	Boot	Basket
Mean	Bottom	Slice	Stool	Air	Stethoscope	Inch	Juice
Calm	Coal	Wine	Sitting	Shiver	Surgeon	Sock	Salad
Emotion	Brown	Loaf	Rocking	Arctic	Clinic	Smell	Bowl
Enrage	Gray	Toast	Bench	Frost	Cure	Mouth	Cocktail
List 9	List 10	List 11	List 12	List 13	List 14	List 15	List 16
GIRL	**HIGH**	**KING**	**MAN**	**MOUNTAIN**	**MUSIC**	**NEEDLE**	**RIVER**
Boy	Low	Queen	Woman	Hill	Note	Thread	Water
Dolls	Clouds	England	Husband	Valley	Sound	Pin	Stream
Female	Up	Crown	Uncle	Climb	Piano	Eye	Lake
Young	Tall	Prince	Lady	Summit	Sing	Sewing	Mississippi
Dress	Tower	George	Mouse	Top	Radio	Sharp	Boat
Pretty	Jump	Dictator	Male	Molehill	Band	Point	Tide
Hair	Above	Palace	Father	Peak	Melody	Prick	Swim
Niece	Building	Throne	Strong	Plain	Horn	Thimble	Flow
Dance	Noon	Chess	Friend	Glacier	Concert	Haystack	Run
Beautiful	Cliff	Rule	Beard	Goat	Instrument	Thorn	Barge
Cute	Sky	Subjects	Person	Bike	Symphony	Hurt	Creek
Date	Over	Monarch	Handsome	Climber	Jazz	Injection	Brook
Aunt	Airplane	Royal	Muscle	Range	Orchestra	Syringe	Fish
Daughter	Dive	Leader	Suit	Steep	Art	Cloth	Bridge
Sister	Elevate	Reign	Old	Ski	Rhythm	Knitting	Winding

List 17	List 18	List 19	List 20	List 21	List 22	List 23	List 24
ROUGH	**SLEEP**	**SLOW**	**SOFT**	**SPIDER**	**SWEET**	**THIEF**	**WINDOW**
Smooth	Bed	Fast	Hard	Web	Sour	Steal	Door
Bumpy	Rest	Lethargic	Light	Insect	Candy	Robber	Glass
Road	Awake	Stop	Pillow	Bug	Sugar	Crook	Pane
Tough	Tired	Listless	Plush	Fright	Bitter	Burglar	Shade
Sandpaper	Dream	Snail	Loud	Fly	Good	Money	Ledge
Jagged	Wake	Cautious	Cotton	Arachnid	Taste	Cop	Sill
Ready	Snooze	Delay	Fur	Crawl	Tooth	Bad	House
Coarse	Blanket	Traffic	Touch	Tarantula	Nice	Rob	Open
Uneven	Doze	Turtle	Fluffy	Poison	Honey	Jail	Curtain
Riders	Slumber	Hesitant	Feather	Bite	Soda	Gun	Frame
Rugged	Snore	Speed	Furry	Creepy	Chocolate	Villain	View
Sand	Nap	Quick	Downy	Animal	Heart	Crime	Breeze
Boards	Peace	Sluggish	Kitten	Ugly	Cake	Bank	Sash
Ground	Yawn	Wait	Skin	Feelers	Tart	Bandit	Screen
Gravel	Drowsy	Molasses	Tender	Small	Pie	Criminal	Shutter

List 1 to List 16 appeared in the tape player.

The words in the ranks of 1, 8, and 10 of each list were used as the old words in the questionnaires (R1 and R2). The words from the remaining lists (List 17 to List 24) that did not appear in the 16 presented lists of the same ranks (1, 8, and 10) including critical lures of these lists were used as new words. The R1 form derived from List 1-4, 9-12, and 17-20. The R2 form derived from List 4-8, 13-16, and 21-24. The bold capital words were critical lures which did not appear in the tape player.

FORM R1

Circle either the word **"old"** or **"new"** to indicate whether the item was presented by means of the tape player.

test items	old (studied)	new (nonstudied)
1. man	old	new
2. anger	old	new
3. butter	old	new
4. cliff	old	new
5. coarse	old	new
6. rough	old	new
7. rule	old	new
8. queen	old	new
9. black	old	new
10. traffic	old	new
11. blanket	old	new
12. cushion	old	new
13. girl	old	new
14. grief	old	new
15. mad	old	new
16. flour	old	new
17. touch	old	new
18. fight	old	new
19. fast	old	new
20. low	old	new
21. hard	old	new
22. bread	old	new
23. smooth	old	new
24. niece	old	new
25. death	old	new

FORM R1

test items	old (studied)	new (nonstudied)
26. white	old	new
27. dough	old	new
28. high	old	new
29. hesitant	old	new
30. soft	old	new
31. beard	old	new
32. building	old	new
33. slow	old	new
34. slumber	old	new
35. strong	old	new
36. boy	old	new
37. bed	old	new
38. riders	old	new
39. wrath	old	new
40. beautiful	old	new
41. chair	old	new
42. sleep	old	new
43. throne	old	new
44. table	old	new
45. king	old	new
46. woman	old	new
47. sofa	old	new
48. feather	old	new

FORM R2

Circle either the word **"old"** or **"new"** to indicate whether the item was presented by means of the tape player.

test items	old (studied)	new (nonstudied)
1. bite	old	new
2. nurse	old	new
3. patient	old	new
4. frame	old	new
5. spider	old	new
6. thief	old	new
7. music	old	new
8. hot	old	new
9. sweet	old	new
10. tarantula	old	new
11. nice	old	new
12. banana	old	new
13. barge	old	new
14. weather	old	new
15. cherry	old	new
16. thorn	old	new
17. cold	old	new
18. flow	old	new
19. horn	old	new
20. soda	old	new
21. goat	old	new
22. web	old	new
23. river	old	new
24. walk	old	new
25. rob	old	new

FORM R2

test items	old (studied)	new (nonstudied)
26. mountain	old	new
27. hill	old	new
28. thimble	old	new
29. foot	old	new
30. instrument	old	new
31. physician	old	new
32. doctor	old	new
33. sour	old	new
34. arm	old	new
35. window	old	new
36. chilly	old	new
37. apple	old	new
38. note	old	new
39. water	old	new
40. shoe	old	new
41. plain	old	new
42. steal	old	new
43. fruit	old	new
44. open	old	new
45. gun	old	new
46. thread	old	new
47. needle	old	new
48. door	old	new

Appendix E: Big Five Personality

We are interested in the extent to which each of the following adjectives applies to you in general. Under each adjective, please circle the appropriate number, on a scale from 1 to 7, where 1 indicates that the term *doesn't apply* to you *at all*, and 7 indicates that it applies *completely*:

TALKATIVE
1--------2-------3------4------5-------6-------7

SYMPATHETIC
1--------2-------3------4------5-------6-------7

ORGANISED
1--------2-------3------4------5-------6-------7

CALM
1--------2-------3------4------5-------6-------7

CREATIVE
1--------2-------3------4------5-------6-------7

EXTRAVERTED
1--------2-------3------4------5-------6-------7

KIND
1--------2-------3------4------5-------6-------7

NEAT
1--------2-------3------4------5-------6-------7

IMAGINATIVE
1--------2-------3------4------5-------6-------7

ASSERTIVE
1--------2-------3------4------5-------6-------7

WARM
1--------2-------3------4------5-------6-------7

ORDERLY
1--------2-------3------4------5-------6-------7

1= DOES NOT APPLY AT ALL, 7 = APPLIES COMPLETELY

STABLE
1--------2-------3------4------5-------6-------7

INTELLECTUAL
1--------2-------3------4------5-------6-------7

FORWARD
1--------2-------3------4------5-------6-------7

UNDERSTANDING
1--------2-------3------4------5-------6-------7

PRACTICAL
1--------2-------3------4------5-------6-------7

ANXIOUS
1--------2-------3------4------5-------6-------7

UNIMAGINATIVE
1--------2-------3------4------5-------6-------7

OUTSPOKEN
1--------2-------3------4------5-------6-------7

INHIBITED
1--------2-------3------4------5-------6-------7

CRUEL
1--------2-------3------4------5-------6-------7

PROMPT
1--------2-------3------4------5-------6-------7

INSECURE
1--------2-------3------4------5-------6-------7

UNINTELLECTUAL
1--------2-------3------4------5-------6-------7

BASHFUL
1--------2-------3------4------5-------6-------7

HARSH
1--------2-------3------4------5-------6-------7

1= DOES NOT APPLY AT ALL, 7 = APPLIES COMPLETELY

METICULOUS
1--------2-------3------4------5-------6-------7
DISORGANISED
1--------2-------3------4------5-------6-------7

SHY
1--------2-------3------4------5-------6-------7

SINCERE
1--------2-------3------4------5-------6-------7

IMPRACTICAL
1--------2-------3------4------5-------6-------7

QUIET
1--------2-------3------4------5-------6-------7

UNKIND
1--------2-------3------4------5-------6-------7

INTROVERTED
1--------2-------3------4------5-------6-------7

UNSYMPATHETIC
1--------2-------3------4------5-------6-------7

SLOPPY
1--------2-------3------4------5-------6-------7

RELAXED
1--------2-------3------4------5-------6-------7

CARELESS
1--------2-------3------4------5-------6-------7

MOODY
1--------2-------3------4------5-------6-------7

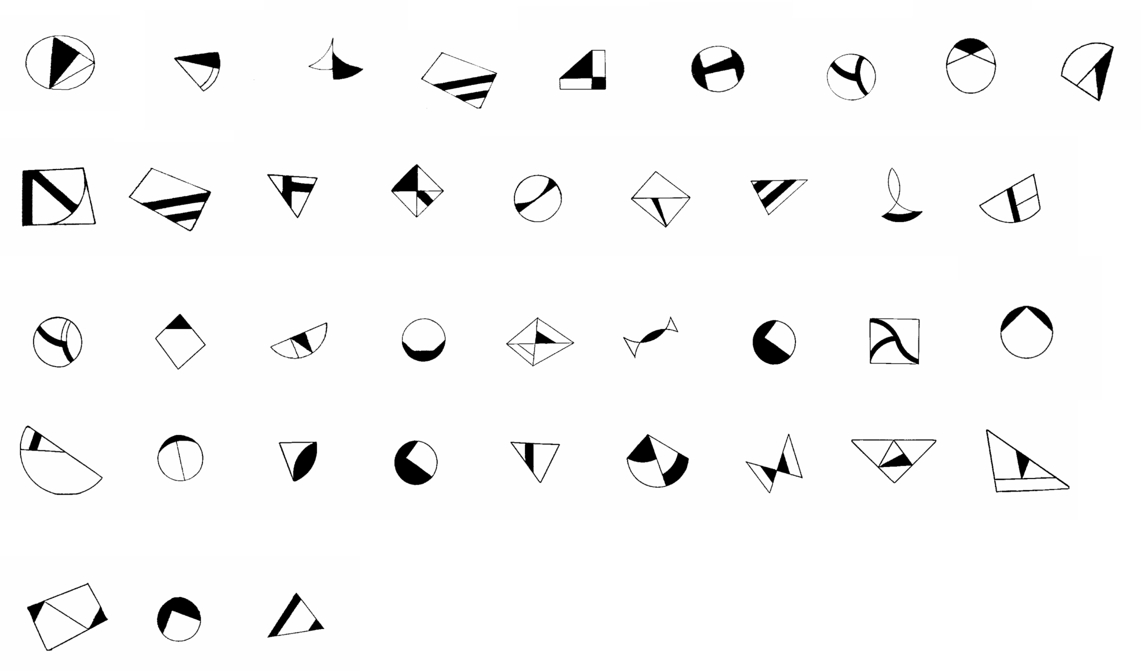
DISORDERLY
1--------2-------3------4------5-------6-------7

UNCREATIVE
1--------2-------3------4------5-------6-------7

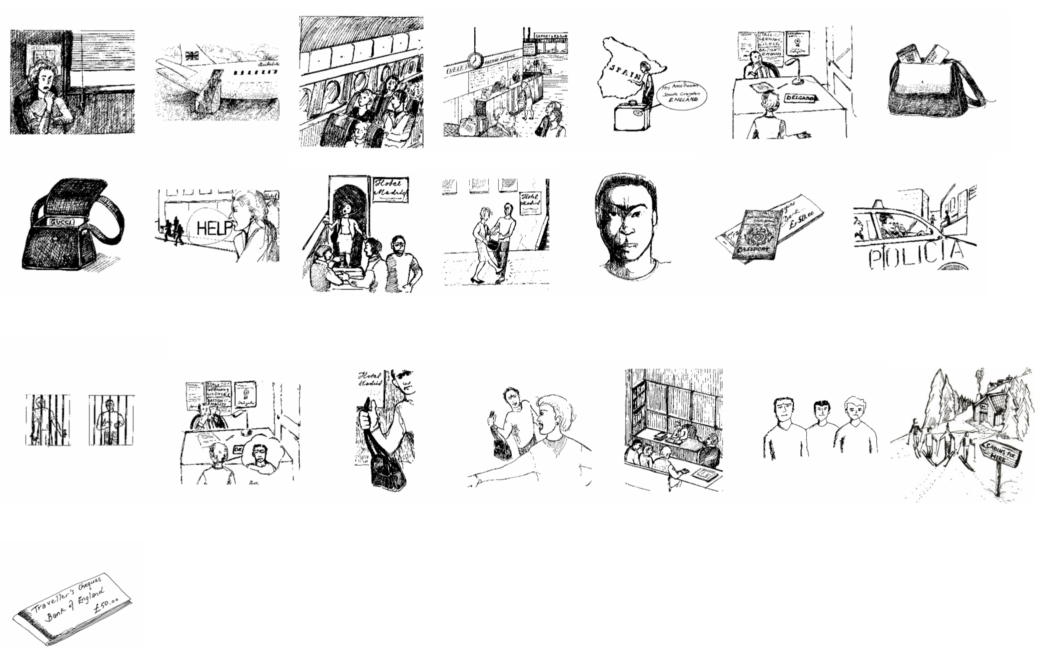
Appendix F

Stimuli pictures

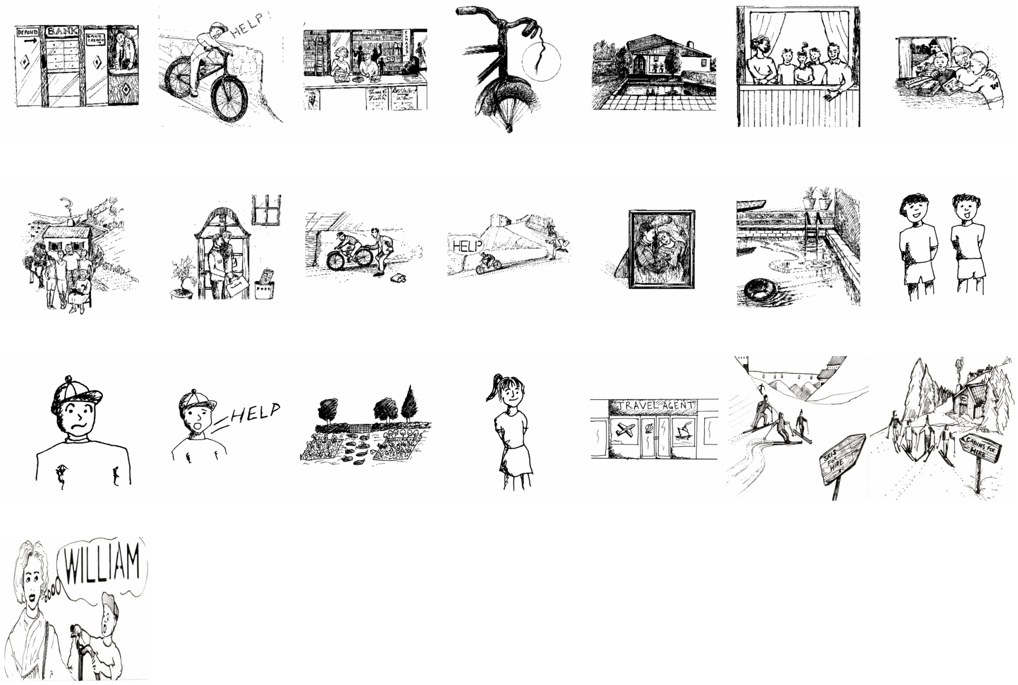
Condition1



GSS1



GSS2



Appendix G: Instructions

Instruction for the DRM paradigm

You will participate in a memory experiment in which you will hear lists of words presented by means of a tape player. After each list, you will hear a sound indicating that you should recall items from the list. You have to listen carefully to each list and the sound will occur after the list has been presented, then you start writing down the words, no need to be in order. Words were recorded in a male voice approximately 1.5 s rate. You will be given 2 min. after each list to recall the words. You have to write down your recalled words on the sheet of paper that will be provided, stating list 1, list 2, until list 16. There are 15 words in each list. Please write the words *legibly*.

Instruction for listening to GSS stories

I want you to listen to a short story. Listen carefully because when I am finished I want you to tell me everything you remember.

Instruction for immediate and delayed recall

Now tell me everything you remember about the story.

Instruction for the oddball task

This is the computerized recognition phase of the experiment. You will see drawing pictures. There are three types of pictures. Most of them are geometric shapes. Occasionally, you will see the pictures that are relevant to the story you have just heard and occasionally also you will see the pictures that are not relevant to the story you have just heard. Your task is to press the LEFT* button, when you see the pictures that are relevant to the story you heard. In contrast, you press the RIGHT* button, when you see the pictures that are not relevant to the story you heard. However, when you see the geometric shape, you don't have to press any buttons, just let them pass.

You are required to press the button as soon and accurate as possible before the new picture appears and try to sit still. Don't move your head and neck. If you want to blink, you can have a quick blink after the pictures disappear. Keep your eyes fixed at the centre of the screen. This is because the brain waves are affected by any movement and blinking.

(*left and right were counterbalanced across participants.)

Instruction for the interrogation procedure

I am going to ask you some questions about the story. Try to be as accurate as you can.

Instruction for the negative feedback

You have made a number of errors. It is therefore necessary to go through the questions one more, and this time try to be more accurate.

Appendix H: Examples of the questionnaire for comparing the differences between GSS1 and GSS2 (conducted in New Zealand). The full questionnaire has 44 items.

After seeing each picture, please identify that the picture is "old" (studied) or "new" (nonstudied). If it is "old", please identify it as "know" or "remember" and rate the degree of it accordingly. "Remember" judgements were made when you can mentally relive the experience (e.g. recalling the contexts, physical characteristics associated with its presentation). "Know" judgements were made when you are confident that the item occurred on the list but are unable to reexperience (i.e. remember) its occurrence.

1 = A little familiar…………………………….7 = Extremely familiar

1) **Old?** □→ Know□ → 1……..2……..3……..4……..5……..6……..7

Remember □→ 1……..2……..3……..4……..5……..6……..7

1 = Remember very dimly…………………………7 = Remember very clearly

OR

New? □

1 = A little familiar…………………………….7 = Extremely familiar

2) **Old?** □→ Know□ → 1……..2……..3……..4……..5……..6……..7

Remember □→ 1……..2……..3……..4……..5……..6……..7

1 = Remember very dimly…………………………7 = Remember very clearly

OR

New? □

1 = A little familiar…………………………….7 = Extremely familiar

3) **Old?** □→ Know□ → 1……..2……..3……..4……..5……..6……..7

Remember □→ 1……..2……..3……..4……..5……..6……..7

1 = Remember very dimly…………………………7 = Remember very clearly

OR

New? □

1 = A little familiar…………………………….7 = Extremely familiar

4) **Old?** □→ Know□ → 1……..2……..3……..4……..5……..6……..7

Remember □→ 1……..2……..3……..4……..5……..6……..7

1 = Remember very dimly…………………………7 = Remember very clearly

OR

New? □

1 = A little familiar…………………………….7 = Extremely familiar

5) **Old?** □→ Know□ → 1……..2……..3……..4……..5……..6……..7

Remember □→ 1……..2……..3……..4……..5……..6……..7

1 = Remember very dimly…………………………7 = Remember very clearly

OR

New? □

Appendix I

Standardisation of the GSS scales

Gudjonsson (1997)'s norms were not presented separately for men and women due to no significant differences in suggestibility and compliance between men and women in his norms. The number of participants was not equal for each variable because some participants completed only immediate recall and refused to continue after the negative feedback.

Norms for the GSS1

Table below gives means and standard deviations for memory and suggestibility for 157 adults in the general population. There were 91 males and 66 females. The mean age of the sample was 29 years (SD=8.9, range 16-62 years). These comprised people in various socio-economic groups, such as unskilled labourer, unemployed people, semi-skilled people, and professionals.

Means and Standard Deviations on the GSS1 for adults in the general population (from Gudjonsson, 1997)

GSS1 subscales	N	Mean	SD	Range
Immediate recall	157	21.3	7.1	4-36
Delayed recall	135	19.5	7.5	4-34.5
Yield1	157	4.6	3.0	0-13
Yield2	157	5.6	3.8	0-15
Shift	157	2.9	2.5	0-12
Total Suggestibility	157	7.5	4.6	0-21

Norms for the GSS2

Table below gives means and standard deviations for memory and suggestibility for 83 normal subjects. There were 53 males and 30 females. The mean age of the sample was 30 years (SD=8.8, range 16-69 years). The participants also comprised various groups of people as for GSS1.

Means and Standard Deviations on the GSS2 for adults in the general population (from Gudjonsson, 1997)

GSS2 subscales	N	Mean	SD	Range
Immediate recall	83	19.7	6.1	8-35
Delayed recall	83	18.4	6.0	4-31
Yield1	83	4.5	3.6	0-13
Yield2	83	5.5	4.0	0-14
Shift	83	3.0	3.0	0-17
Total Suggestibility	83	7.5	5.3	0-22